ISSN 0704-3716

Canadian Translation of Fisheries and Aquatic Sciences

No. 5319

Semi-Intensive lobster cultivation. Transfer of techology from experimental production to pre-commercial production

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Original title: Transfert technologique de l'elevage semi-intensif de homard du niveau experimental au niveau pre-commercial

Ref: Les Crustaces Vivants Madelinots Inc., P.O. Box 182, Cap-aux-Meules, Magdalen Islands, Quebec G0B 1B0, 158 p.

Original language: French

Available from:
Canada Institute for Scientific and Technical Information
National Research Council
Ottawa, Ontario, Canada K1A 0S2

1987

122 typescript pages

Contract No. LSO-6-02169

Translation request No. 2894109

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TRANSFER OF TECHNOLOGY

FROM EXPERIMENTAL PRODUCTION TO PRE-COMMERCIAL PRODUCTION

90-02108/

SEMI-INTENSIVE LOBSTER CULTIVATION

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FROM EXPERIMENTAL PRODUCTION TO PRE-COMMERCIAL PRODUCTION

Submitted to:

DEPARTMENT OF FISHERIES AND OCEANS

by:

LES CRUSTACES VIVANTS MADELINOTS INC.

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MARCH 1985

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INTRODUCTION

A suspended floating system for the semi-intensive cultivation of lobsters of commercial size was designed in 1983 (Fradette 1984 a). The first trial of this experimental system yielded encouraging results with respect to the keeping and fattening of lobsters (Fradette 1984 a and b). This initial effort gave rise to a recommendation to the effect that it would be desirable to design a floating structure specifically adapted to the requirements of the operation, in order to facilitate handling of the stacks of trays containing the lobsters. The floating building inside which these handling operations would take place should also be designed with a view to greater stocking capacity for commercial purposes.

The main objective of this project is to develop the suspended floating lobster cultivation system and to use it on a trial basis for production on a pre-commercial scale. We assess the time required for the various operations and the number of personnel needed, and as a result are able to measure the capacity of the system. In order to determine whether functional improvements would lead to changes with respect to the survival, growth and quality of the lobsters, we conducted a biological follow-up to the lobster cultivation project. We present our findings relating to marketing. Lastly, integration of all costs and income has enabled us to carry out the first economic feasibility study of a firm engaging in the semi-intensive cultivation of lobsters. We propose various technological and biological improvements with a view to enabling such a firm to become economically viable.

MATERIALS AND METHODS

1. Lobster cultivation project site

1.1 Geographical location

The lobster cultivation system was moored in the Havre-aux-Maisons lagoon, in one of the branches of the channel communicating with the mouth of the lagoon (figure 1). The position was 15 metres north of the island known as l'Île Rouge, and there was a distance of approximately 700 metres between the site and the Havre-aux-Maisons wharf. At the project site, the depth of the channel is eight metres and its maximum width, 30 metres.

The island constitutes a natural barrier affording protection against south winds. When the wind blows from some other quarter, the shoals bordering the channel exert a damping effect on the waves that form in the eastern and western basins of the lagoon. The height of the waves at the lobster cultivation project site may be as much as 0.25 metre.

1.2 Physical and chemical conditions

1.2.1 Materials and methods

We determined the physical and chemical conditions obtaining in the surface waters at the lobster cultivation project site and compared our findings with those for three other potential cultivation sites in the Havre-aux-Maisons lagoon. The locations of the sampling stations are shown in figure 1.

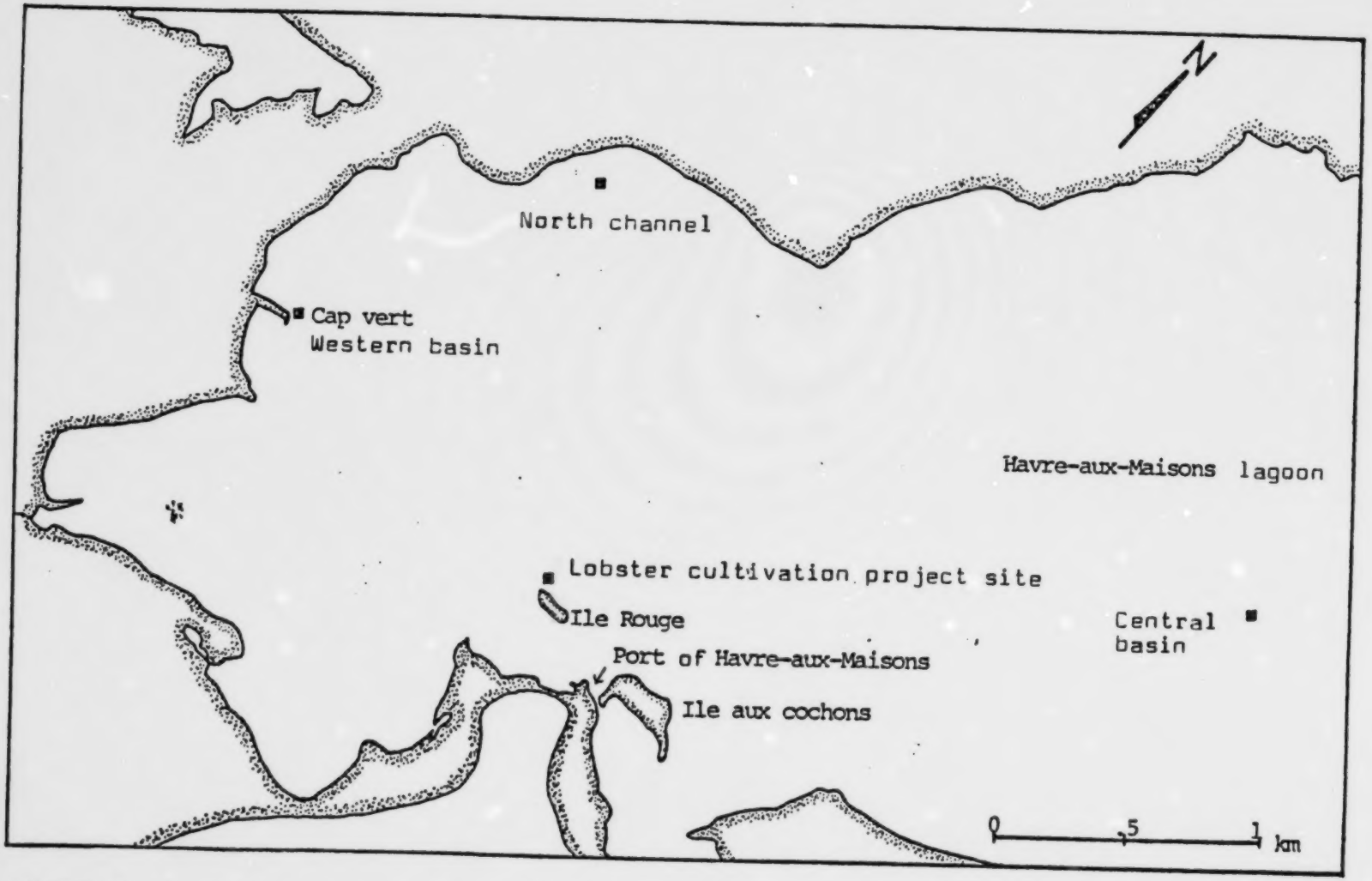


Figure 1 . The Havre-aux-Maisons lagoon, showing the locations of the 1984 lobster cultivation project site and the 1983 sampling stations: western basin, north channel, central basin.

At the project site, the temperature was continuously recorded at a depth of 2.5 metres from June 30 to November 3, 1983 and at 0.1 metre from June 20 to November 2 and from November 14 to December 2, 1984. At all four sampling stations, dissolved oxygen and temperature levels at a depth of one metre were recorded at regular intervals during the summer of 1983. The instrument used was a YSI Model 57 oxygen meter. Simultaneously, 250 ml water samples were taken at the surface for laboratory analysis of pH and ammonia content. The pH and ammonia values were determined by means of a Corning Model 130 pH-ion-meter with an accuracy of 0.002 in the case of the pH and of 0.01 mg/l in the case of ammonia. This instrument featured a Corning combined electrode for pH and an Orion selective electrode for un-ionized ammonia. In carrying out these chemical analyses, we followed the recommendations of Greenberg et al (1981).

We monitored changes in temperature, oxygen, pH, ammonia and current during several twelve-hour tide cycles at the project site. The measurements were taken every half hour at a depth of one metre. This type of sampling was conducted on eight occasions in 1983, on August 9, 19 and 25, September 1, 8, 15 and 22, and October 20. To measure water current speeds we used a General Oceanics Model 2035 current meter.

1.2.2 Temperature

Lobsters are found in waters the temperature of which may range from 2°C to 25°C (Aiken 1980). They are capable of becoming acclimatized to values as low as 0°C and as high as 30°C; however, such extremes of temperature considerably reduce their chances for survival.

Water temperature may play an important role in the growth of lobsters. According to Hugues et al (1972), optimum conditions for growth occur at a temperature of between 20°C and 22°C. In the lagoon, these temperatures are attained for a period of between 0 and 34 days during the summer.

We compiled temperature data collected to date in the Havre-aux-Maisons lagoon, and the results are shown in figure 2. The weekly minimum and maximum temperatures observed from May to December are indicated. During this period the temperature regime is initially characterized by warming in spring, followed by high temperatures in summer, with maximum values ranging between 17°C and 23.5°C, and finally progressive cooling during the autumn, when the water temperature may go as low as 2°C. The 1983 and 1984 data show that the temperature regime may vary considerably from one year to the next (figure 3): for example, the cumulative number of degree-days between the beginning of July and the end of September was substantially greater in 1984 than in 1983. Furthermore, the cooling of the water during the autumn proceeded much more slowly in 1984.

1.2.3 Salinity

Salinity was not evaluated at the project site. However, the measurements reported by Gagnon et al (1984) and by Poirier and Myrand (1982) show that the values range between 28.0 and 31.6 ‰ in the western and central parts of the Havre-aux-Maisons lagoon between June and November. The highest values are observable in August, and thereafter salinity declines progressively

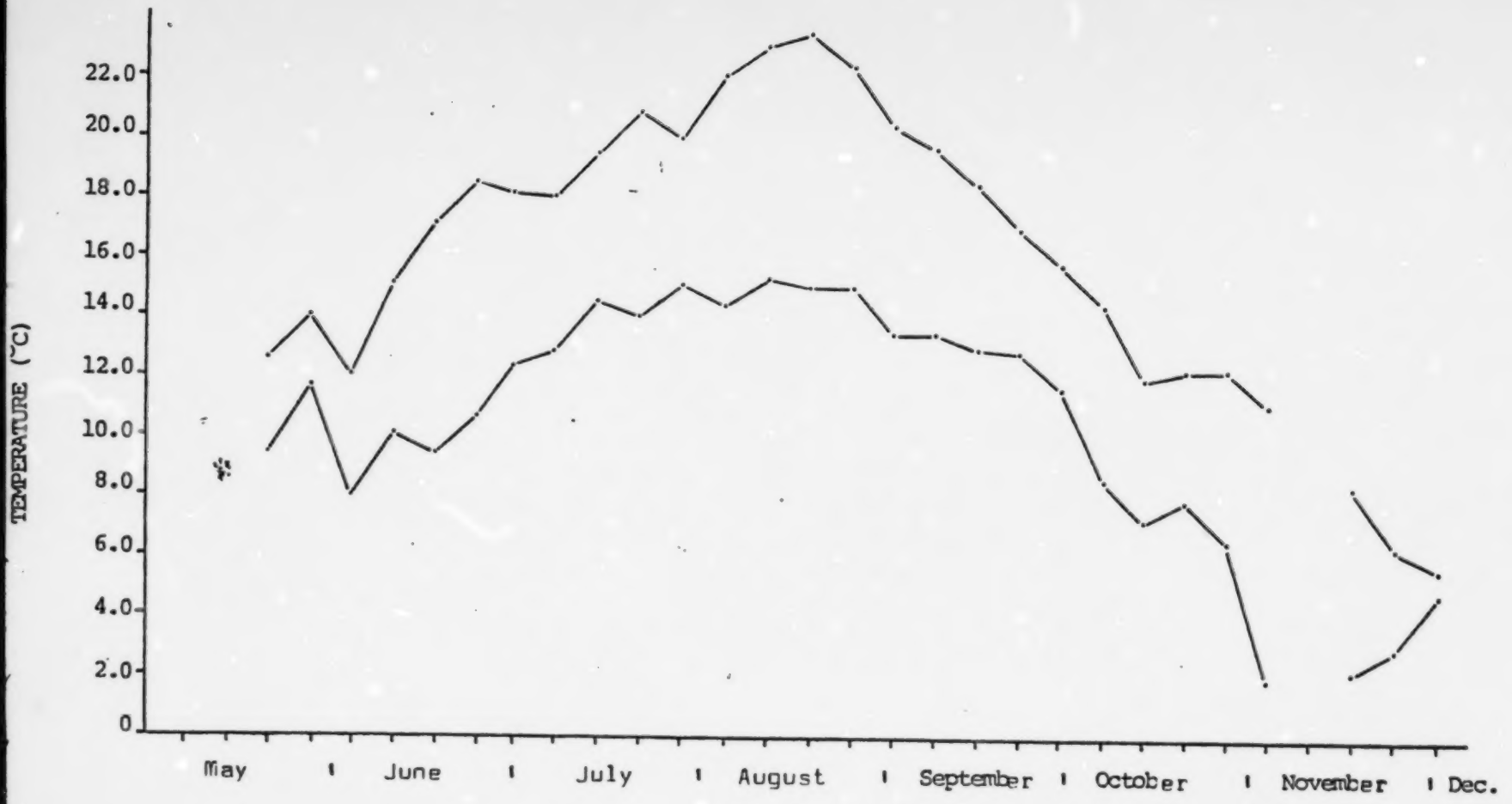


Figure 2. Seasonal changes in weekly minimum and maximum temperatures in the Havre-aux-Maisons lagoon. The data have been compiled from the work of Boucher (1964), Auclair (1977), De Sèvre et al. (1978), Munro and Thérriault (1981), Poirier and Myrand (1982) and Gagnon et al. (1984), covering the years 1964, 1974, 1975, 1976, 1977, 1978, 1979 and 1982, in addition to the data contained in this report for 1983 and 1984.

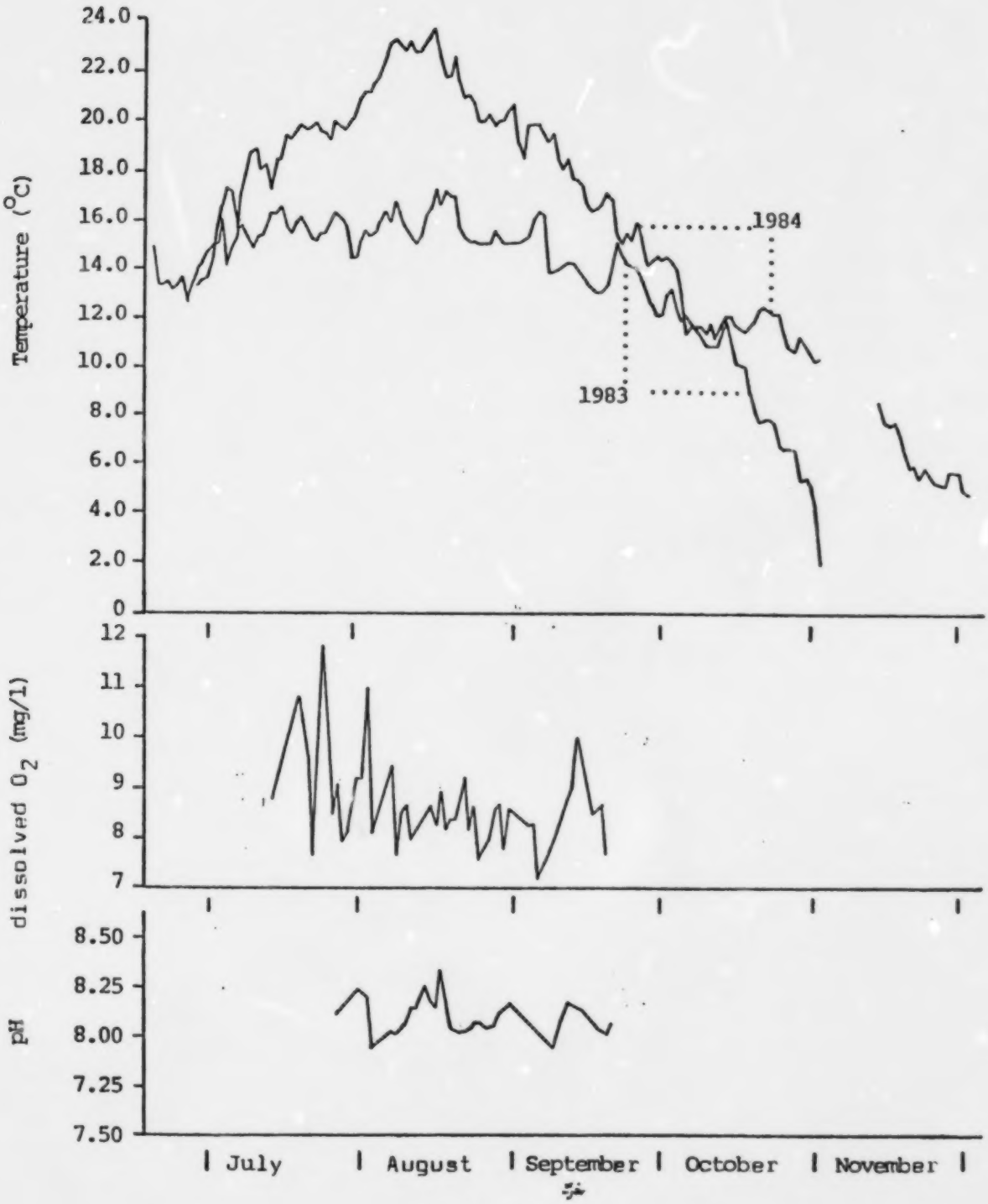


Figure 3. Changes over time in (a) temperature in 1983 and 1984, (b) dissolved oxygen content, and (c) pH values at the lobster cultivation project site in 1984.

until November. Precipitation and water mass exchanges with the tides cause small fluctuations (less than 2‰). At no time are salinity values such as to jeopardize the growth and survival of lobsters.

1.2.4 Dissolved oxygen

The dissolved oxygen content remained consistently at values greater than 7 mg/l at the lobster cultivation project site during the summer. Dissolved oxygen concentrations ranged between 7.2 mg/l and 11.8 mg/l (figure 3 b). The mean summer value is 8.7 (s: 0.9) mg/l. These values are higher than the optimum concentration of 6.4 mg/l given by Gates et al (1974).

Fluctuations over a twelve-hour cycle do not exceed 1.5 mg/l, as can be seen from figures 4 to 7. In general, the lowest concentrations are observed when current speeds are low. Other factors that may affect dissolved oxygen content in the short or long term are agitation of the surface water, temperature, and salinity.

1.2.5 Un-ionized ammonia

Nitrogen content, in the form NH_3-N, fluctuates between 0.02 mg/l and 1.8 mg/l at the project site (figures 4 to 7). Delistray et al (1977) and Sastray and Laczak (1975) have determined that optimum values for the survival of larvae and juveniles should be inferior to 0.14 mg/l and 9.4 mg/l of NH_3-N respectively. Although optimum conditions for adults are not specified, it appears that the toxicity of this compound varies inversely with the age of the specimens concerned. The maximum

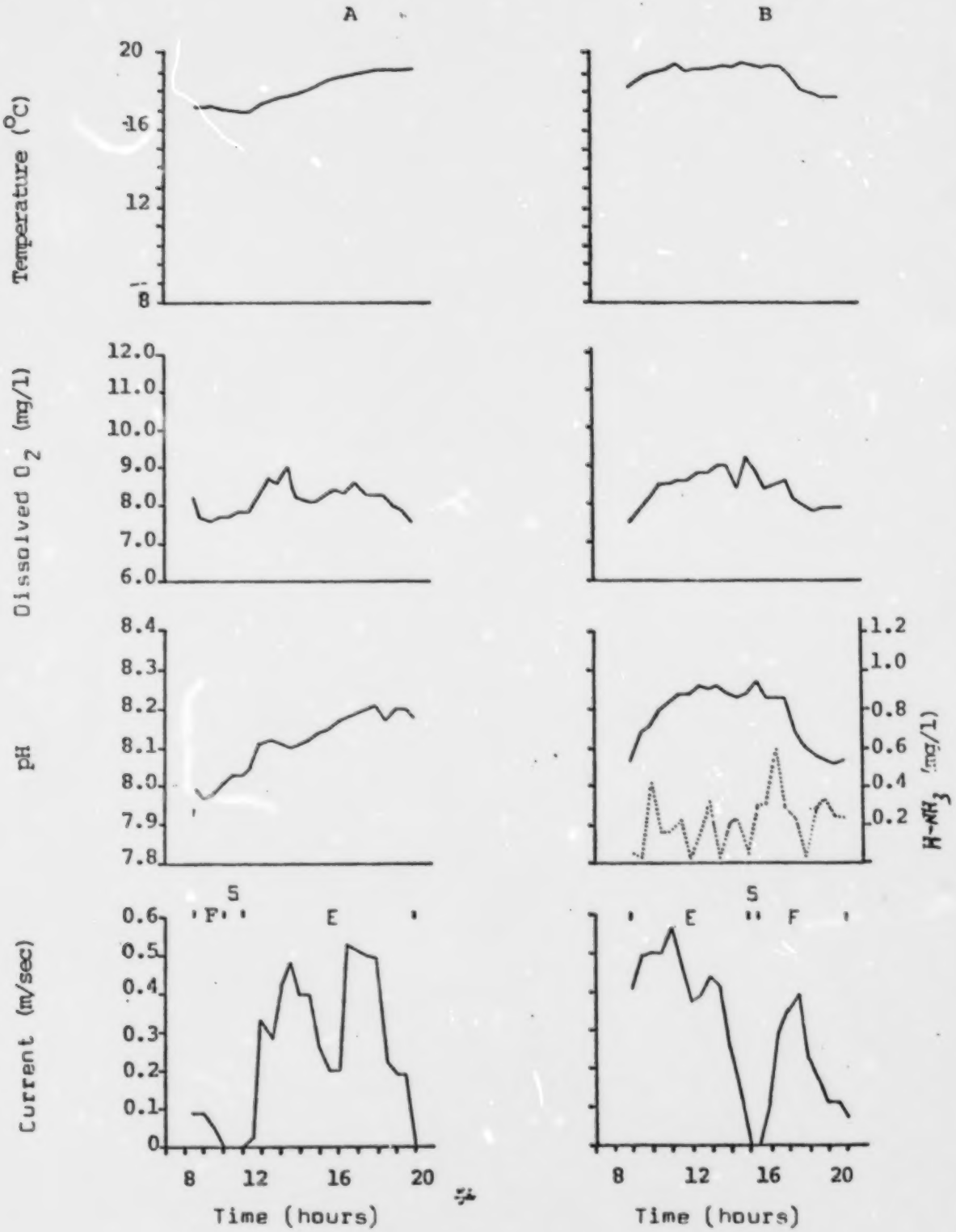


Figure 4. Changes over a twelve-hour cycle in temperature, dissolved oxygen content, pH, ammonia concentration (.....) and current speed at the lobster cultivation project site on (a) August 4 and (b) August 18, 1983. (F = flood; S = slack water; E = ebb)

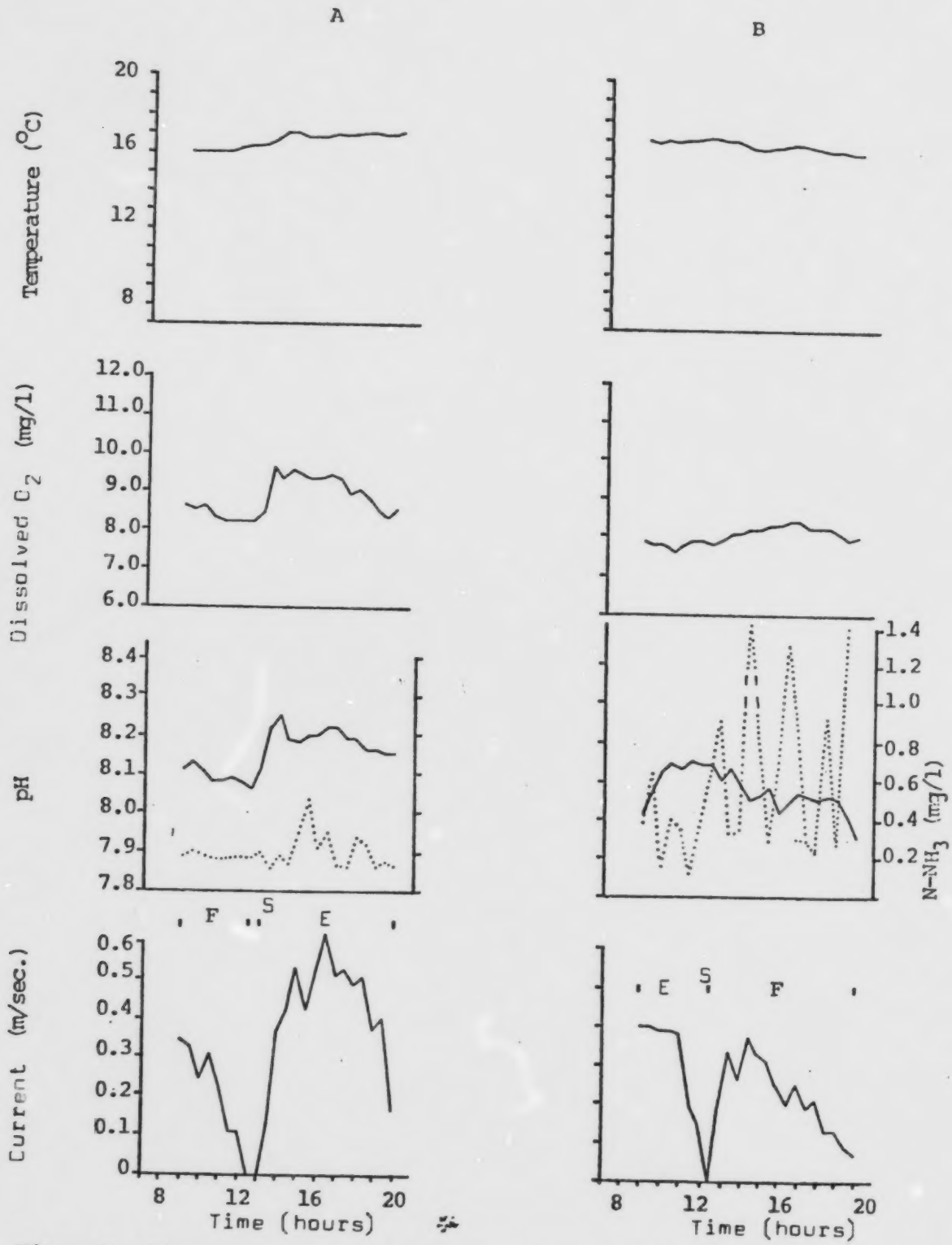


Figure 5. Changes over a twelve-hour cycle in temperature, dissolved oxygen content, pH, ammonia concentration (.....) and current speed at the lobster cultivation project site on (a) August 25 and (b) September 1, 1983. (F = flood; S = slack water; E = ebb)

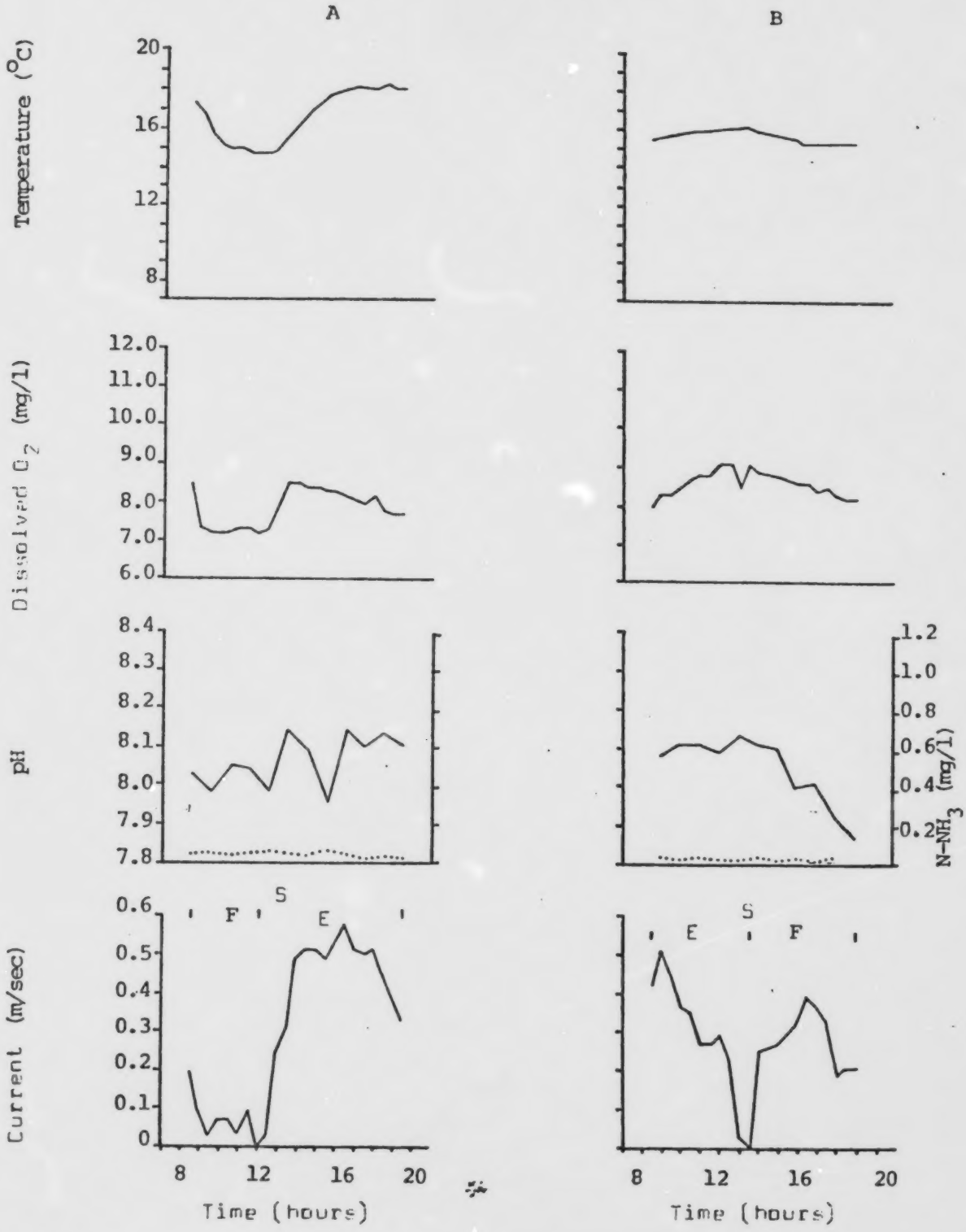


Figure 6. Changes over a twelve-hour cycle in temperature, dissolved oxygen content, pH, ammonia concentration (.....) and current speed at the lobster cultivation project site on (a) September 8 and (b) September 15, 1983. (F = flood; S = slack water; E = ebb)

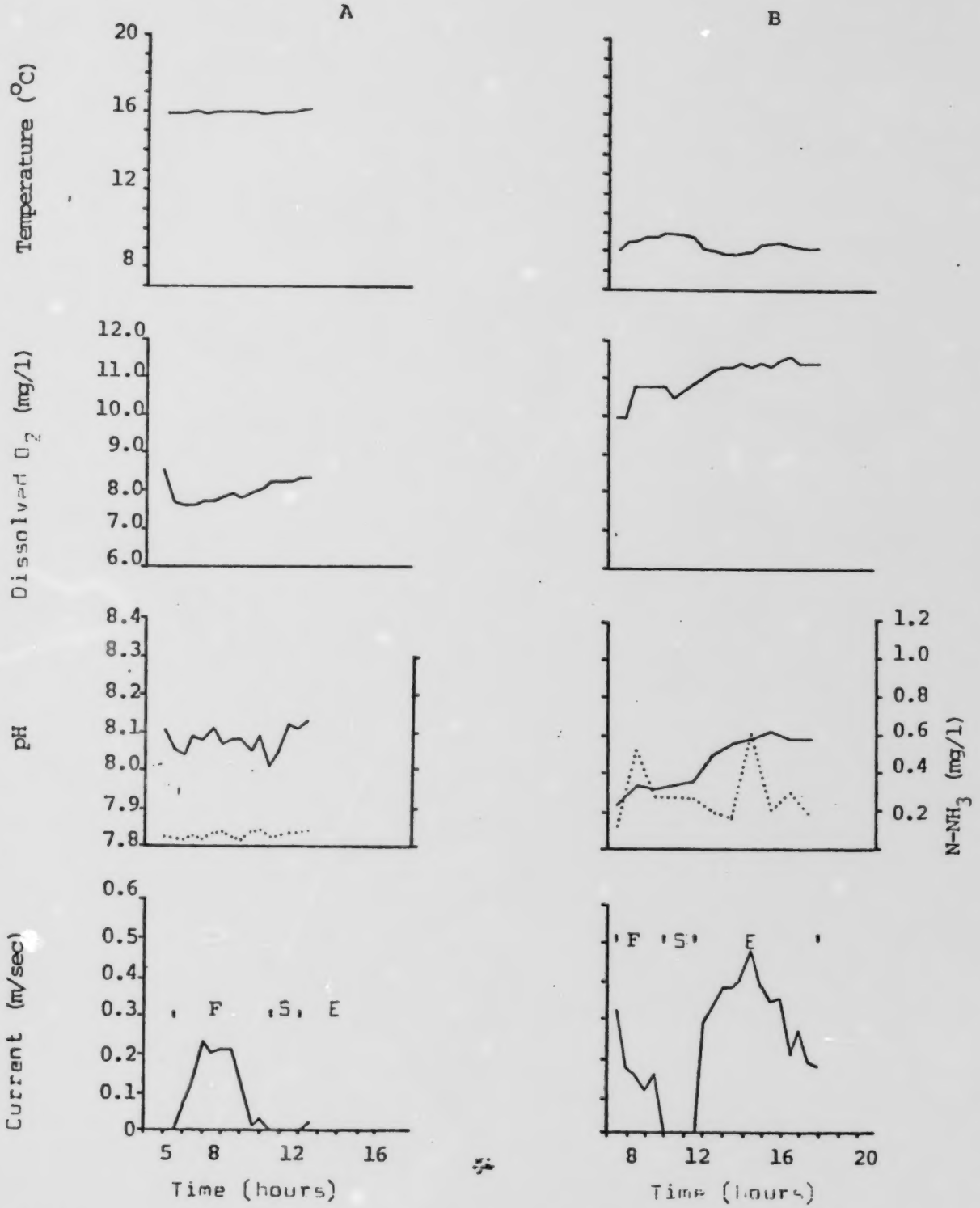


Figure 7. Changes over a twelve-hour cycle in temperature, dissolved oxygen content, pH, ammonia concentration (.....) and current speed at the lobster cultivation project site on (a) September 22 and (b) October 20, 1983. (F = flood; S = slack water; E = ebb)

value observed at the project site (1.8 mg/l) is well below the optimum threshold value of 9.4 mg/l of NH_3-N applicable to juveniles. Furthermore, the cultivated lobsters were adults, whose upper limit for optimum NH_3-N conditions may be higher.

1.2.6 pH

The pH value expresses the relationship between concentrations of ammonia in ionized form (NH4+) and in un-ionized form (NH3). As un-ionized ammonia is the more toxic of the two (Wuhrman and Woker 1948), variations in pH may be an indicator of environmental quality: high pH values would presumably indicate high concentrations of NH_3. Where pH values are less than 5 or greater than 9, lobsters cannot survive (Harriman 1953).

In 1983 the pH value of the surface waters where the cultivated lobsters were kept remained between 7.95 and 8.27 from late July to late September. The mean pH value for that period is 8.09 ($s = 0.07$).

At the lobster cultivation project site, pH values were higher at the end of the ebb (figures 4 to 7), an observation which suggests that the waters of the lagoon are more basic than those of the Baie de Plaisance.

The observed variations in pH fall within the acceptable range (between 9.0 and 0.3: Anonymous). The mean observed value (8.09) is close to the optimum pH of 8.2 (Anonymous) or 9.0 (Harriman 1953).

1.2.7 Current

Water circulation at the project site is caused primarily by the tidal currents. The speed of these currents is generally greater during the ebb than during the flood (figures 4 to 7). An ebbing current may attain a speed of as much as 0.7 m/sec during periods of spring tides.

2. Physical and chemical characteristics of other potential lobster cultivation sites in the Havre-aux-Maisons lagoon

Physical and chemical data from three other potential lobster cultivation sites in the Havre-aux-Maisons lagoon are shown in table 1. Data relating to temperature, dissolved oxygen, pH and un-ionized ammonia were gathered at regular intervals between mid-July and late September, 1983. Comparison of the mean values of these parameters reveals little difference between the north channel sampling station and those in the western and central basins. Similarly, mean values for temperature, dissolved oxygen and pH at these potential sites are similar to those observed at the actual project site, near the mouth of the lagoon (table 1). However, the daily range of variation in temperature may be greater at the actual site (maximum range: 3.5°C; figures 4 to 7) than in the western basin (maximum range: 1.5°C; Gagnon et al 1984).

Periodic measurements of current speeds at the three potential sites yielded values that were below the detection threshold of the instrument used. According to Gagnon et al (1984), however, it appears that currents in the western basin are related primarily to the strength and direction of the wind. Maximum

Table 1. Monthly mean values for temperature, dissolved oxygen content, pH and ammonia concentration of water at potential lobster cultivation sites. The data were recorded at regular intervals between July 15 and September 22, 1983.

	T^{o} °C			O^{2} mg/l			pH			$N\text{-}NH_{3}$ mg/l		
	n	$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s
Western basin	9	16.8	1.5	9	8.4	.6	9	8.15	.05	7	.34	.32
North channel	9	17.0	1.5	9	8.3	.5	9	8.16	.07	7	.32	.26
Central basin	9	16.9	1.2	9	8.5	.7	9	8.14	.04	7	.44	.44
Lobster cultivation project site	50	16.8	1.0	50	8.7	.7	36	8.09	.07			

observed speeds are of the order of 0.35 m/sec, which is only half the maximum value observed at the actual project site. In addition, the dominant influence of the tide at the actual site produces water mass changes that are much more regular and occur much more rapidly than is the case at the other potential sites, where the dominant influence on water mass changes is probably the wind.

Currents may play a prominent role as a controlling factor in environmental quality in the lobster cultivation facility. Water mass changes may eliminate toxic products such as the ammonia excreted by the lobsters. The lobsters also consume dissolved oxygen, and water mass renewal may be the most effective means of maintaining an adequate concentration of dissolved oxygen in the facility. In view of these two considerations, it appears that the other potential sites are less desirable than the actual project site. This does not necessarily imply, however, that the physical and chemical characteristics of those sites make them unsuitable for lobster cultivation. It is worth noting that part of the lobster population inhabits the lagoon, and that the most densely inhabited area is the western basin (Munro and Therriault 1981).

3. Stocking phase

3.1 Duration of the lobster cultivation project

The stocking of the lobster cultivation project facility lasted from June 12 to the end of the commercial lobster-catching season on July 13, 1984. Feeding, maintenance and sales operations

continued until late in December. The project thus extended over a period of seven months.

3.2 Source of lobsters

We bought 6,479 lobsters from producers. Of this number, 3,560 specimens (1381 kg) were supplied by the Norpro Company of Etang-du-Nord, while 3,189 specimens (1413.5 kg) came from the holding tanks of the Gros-Cap fishermen's co-operative. At Etang-du-Nord the lobsters were held in floating wooden boxes inside the fishing port.

3.3 Selection and transport of lobsters

We used the selection criteria set forth by Gagnon et al (1984). We selected uninjured males having a cephalothorax of between 76 mm and 90 mm in length. The claws of all lobsters selected were bound with elastic bands. Their captivity in the producers' facilities had lasted from one to a maximum of three days. As few lobsters were captured toward the end of the season, we were compelled to purchase a small number of females (913 specimens) and some lobsters with healed injuries.

After selection, the lobsters were kept temporarily in wooden boxes at Etang-du-Nord and in plastic tubs in the holding tanks at Gros-Cap. After weighing them we placed them immediately in the trays in which they were to be kept during the cultivation operation. They were transported to the Havre-aux-Maisons wharf in a pickup truck, and then taken by boat from the wharf to the project facility. Total transport time ranged between 20 minutes

and one hour, depending on the quantity of lobsters being handled and where they were loaded.

4. Feeding

4.1 Sources and types of food

We used the common crab (Cancer irroratus) as the lobsters' basic food. Some 5,477 kgof live crabs were purchased directly from two crab fishermen during the lobster-catching season. As soon as they were brought into port, dead specimens were discarded and the live crabs immediately frozen.

In mid-September, as supplies of crab had run out, we purchased 523 kg of extruded pellets made by Marine Lobster Farms of Prince Edward Island. This frozen moist food was brought in by air in insulated cardboard boxes and placed in a freezer upon arrival. The composition of the pellets is described in Gagnon et al (1984).

Beginning in late September, we gathered young blue mussels to feed lobsters that had recently moulted. These mussels were found on the outer surfaces of the lobster trays and the immersed parts of the lobster cultivation facility. This type of food was used alternately with the pellets.

4.2 Preparation of food and individual portions

Individual portions of food were prepared manually. The crab legs were separated from the bodies and then crushed by means

of a sledgehammer. The bodies were cut into quarters with a cleaver. One body quarter or four or five legs were given to each lobster at a feeding (figure 8 a). The crab body quarters weighed between 25 and 30 grams, and the average weight of one ration of legs was 50 grams. Any lobster that had recently moulted was given double rations.

When the extruded pellets were used, each lobster was given a portion weighing five to six grams at every feeding. Portions of mussels weighed approximately 50 grams. These two types of food did not require any particular preparation.

4.3 Frequency of feeding

As soon as the lobsters were placed in the facility, they were fed at a rate of two to three times per week. Because of the quantity of lobsters and the handling system used, we were unable to feed them as frequently as four times per week, as Fradette had suggested (Fradette, 1984 b). During the season there were several periods of fasting as a result of technical problems: from August 1 to August 10, all the straps and buckles that held the stacks of lobster trays together were replaced, and from August 31 to September 6 the boats used for transport were laid up for repairs. In addition, there were several minor technical problems that slowed down feeding operations. Late in November we discontinued feeding operations because the lobsters had ceased to consume the food they were given.

5. Maintenance

Lobsters and equipment were checked, and any damaged parts

A)

B)

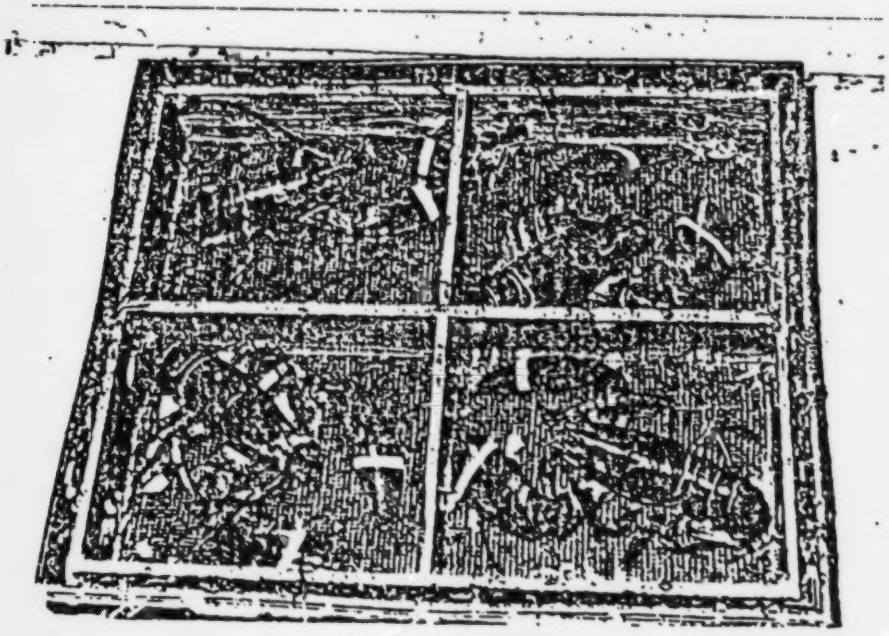


Figure 8. A) Fragments of common crab (Cancer irroratus) used to feed B) lobsters.

of the latter replaced, on the occasion of feeding operations. In addition, the trays were cleaned: this involved the removal of food residues, dead lobsters, and the claws of exuviae. The rest of a shed carapace, however, was left in its owner's compartment, as it was usable for food. We observed that rations consisting of mussels and crab legs produced much greater quantities of residues than crab body quarters. The claws of lobsters that had moulted were not bound with elastic bands, since according to Fradette (1984 a and b) it is not necessary to secure the claws after moulting.

Items of equipment that were subject to damage were the wooden frames, the screens, and the polypropylene trays. In addition, handling sometimes resulted in wear on a strap at the point where it was inserted into the metal buckle. The useful life of the trays is estimated at ten years on average, while the wooden frames and screens may be expected to last an average of two years and the buckles and straps five years.

6. Collection of data for biological follow-up

For the population of the project facility as a whole, we noted the number of specimens that died and the date of each individual's death, the number that moulted and the date of each individual's moult, and changes in the size of the population. We conducted a biological follow-up on a sample of 240 male specimens. The compartments of these specimens were identified so that they could be individually monitored. For each of the lobsters in the experimental group we noted, at the beginning and at the end of the project, the following parameters:

- length of cephalothorax, measured by means of a vernier accurate to within 0.025 mm,
- live weight, the lobster being weighed by means of an electronic balance accurate to within 0.5 gram,
- number and type of injuries,
- stage in moulting cycle, as determined by the hardness-of-carapace method (figure 9) (this information was also recorded in October).

A partial autopsy was carried out on every freshly dead specimen. This autopsy consisted of noting whether any injuries were present, and if so how serious they were, noting the hardness of the carapace, and if possible taking a blood sample to determine whether the lobster had been a victim of gaffkemia. Tests designed to detect the presence of the bacterium Aerococcus viridans (var.) homari were carried out by the competent staff of the scientific and technological research laboratory of the Marine Fisheries Directorate, Department of Agriculture, Fish and Food of Quebec. At the beginning and end of the period of cultivation, and also in October, blood samples were taken from samples of 216, 42 and 20 specimens respectively.

The blood samples taken at the end of the project were also used to determine serum protein concentrations. For this purpose we used a Uricon specific-gravity refractometer, applying the method suggested by Leavitt and Bayer (1977). In October, wet and dry meat yields from ten specimens in the non-moulters and first-period moulters category were assessed. At the end of the

project a similar assessment was made on ten specimens from the same two groups and ten specimens that had moulted in the second period. The method used was the same as that described in Fradette (1984 a and b).

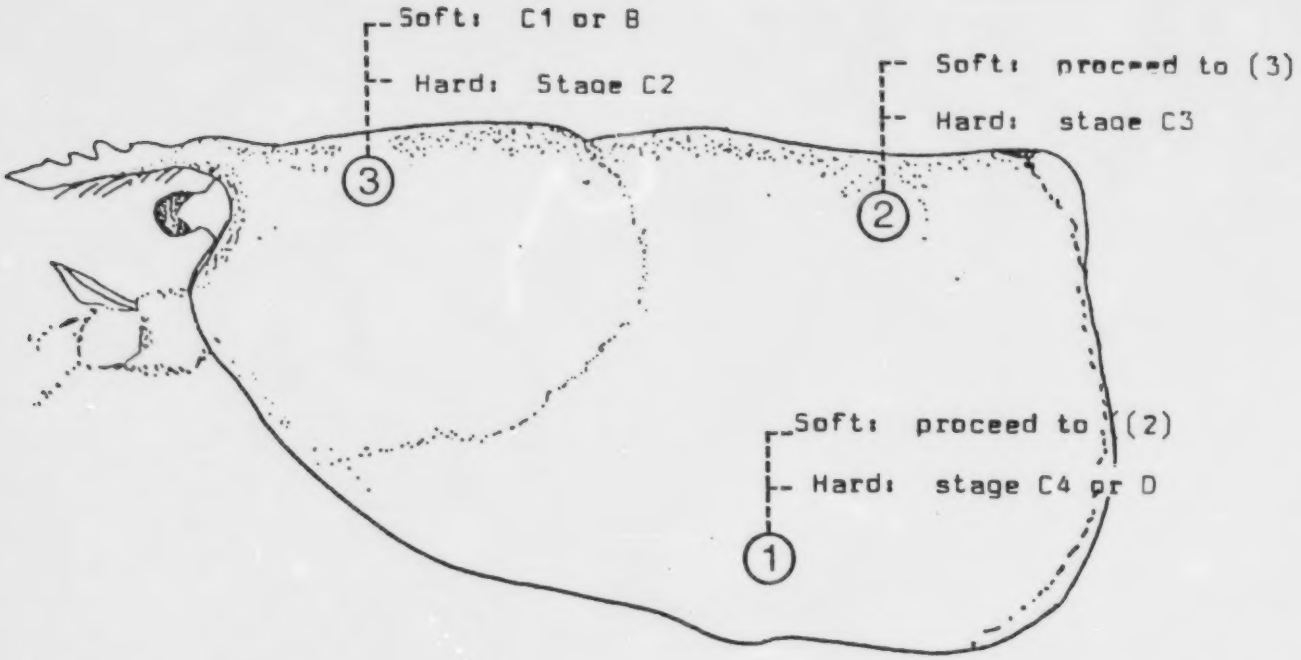


Figure 9. Method used to determine moulting cycle stage from hardness of carapace. The stage in the moulting cycle is determined from successive examination of the three parts (1), (2) and (3) of the cephalothorax. (Aiken 1980)

DESCRIPTION OF THE LOBSTER CULTIVATION SYSTEM

1. Basic features

A suspended floating lobster cultivation system was developed with a view to enhancing stocking capacity and expediting feeding and maintenance operations. The basic features of the system are thus essentially the same as those of the system suggested by Fradette (1984 a). To review those features briefly, we may note that the lobsters are cultivated in their natural environment, and that a floating building is used as a structure for handling movable stacks of trays in which the lobsters are kept. The main components of the system are the divided trays, the floating building and walkways, the anchoring system for these structures, the holding lines, the haul lines, and the stack handling system (figures 10 to 15). The trays containing the lobsters are stacked one on top of another, and the stacks of trays are immersed but kept at the surface by their buoyancy (figure 15). These stacks of trays are strung along a number of nylon rope lines (figure 13). They can be moved horizontally, as they are attached in such a way that they will slide along the holding lines, which are slung between the walkways and the floating building (figure 11). These structures (the walkways and the building) are anchored to the bottom. The feeding procedure involves four main operations: hauling in the stacks of trays, raising the stacks of trays out of the water, the feeding proper, and reimmersion of the stacks of trays. The layout of the strings of stacks on their holding lines is such that opposite every string of stacks there is an empty pair of holding lines on the other side of the building. The strings of stacks of lobster trays are laid out parallel to the direction of the tidal currents, as this

facilitates the task of moving stacks in and out.

2. Equipment

2.1 Divided trays

The divided tray used in the lobster cultivation system is described in Fradette (1984 a). The tray is made of green polypropylene, and it is 63.5 cm long, 53.5 cm wide and 11.0 cm deep. The bottom and sides of the tray are pierced with large numbers of holes. A wooden frame, divided into four quarters by means of partitions, fits inside the tray; the sides of this frame and the partitions consist of boards 1.0 cm thick and 8.2 cm wide. A sheet of plastic screening with 3.5 mm x 2.5 mm oval holes is placed in the bottom of the tray, under the wooden frame. Circulation holes 23 mm in diameter in all four sides of the tray itself and the divided wooden frame constitute the latest improvement to the original design (figure 4 in Fradette 1984 a). These holes and those in the bottom of the tray enable water to circulate more freely inside the tray, and the result is that the water in which the lobsters are raised is of better quality.

A stack consists of fourteen trays piled one on top of another (figure 14). Lobsters are kept in twelve of these; the functions of the top and bottom trays are described in the following paragraphs. A stack is 1.44 m high, and its wet weight is approximately 70 kg. The trays are held securely together by a strap passed around the stack; the strap can be tightened by means of a buckle. To facilitate handling, the buckle is located halfway up the stack. At the beginning of the season plastic buckles were used, but about midsummer these were replaced with

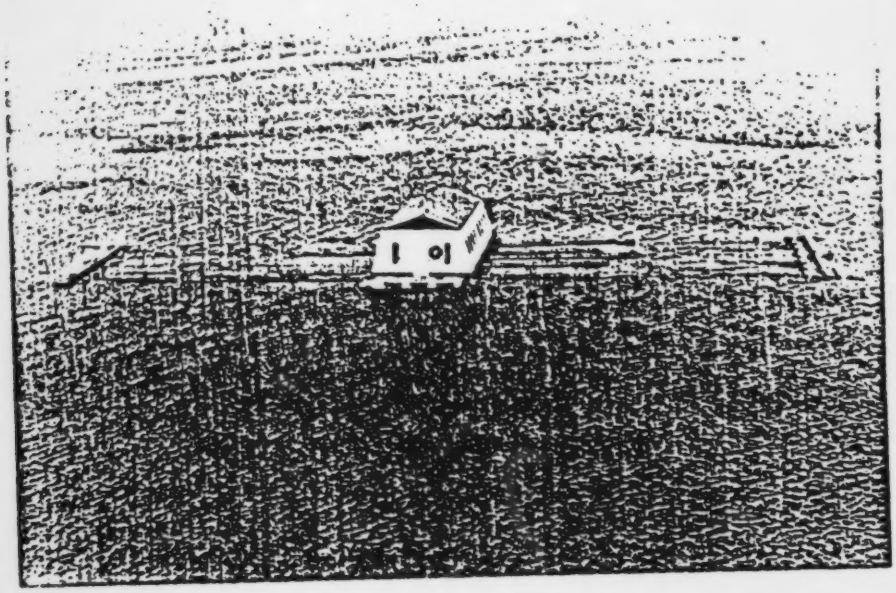


Figure 10. Suspended lobster cultivation system, aerial view.

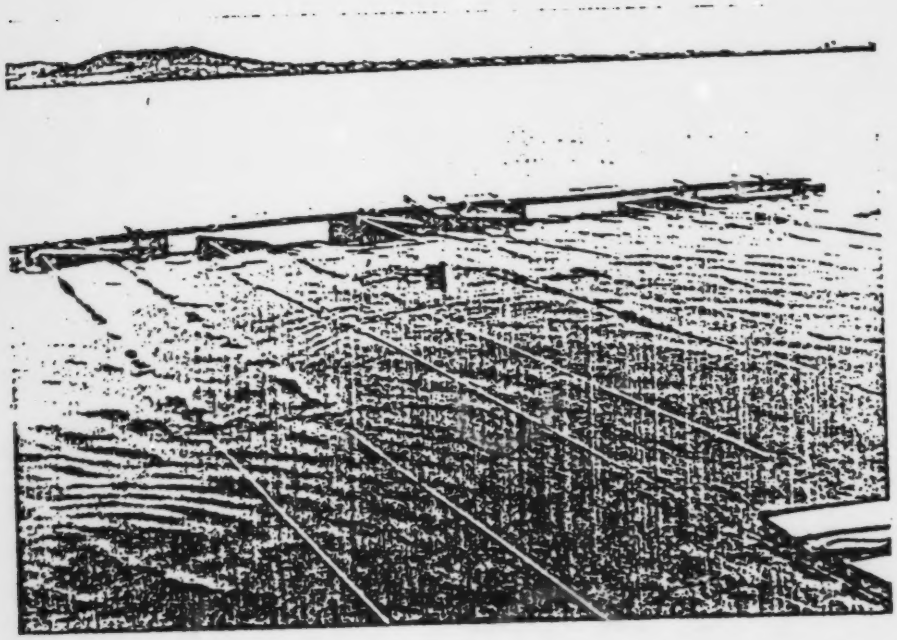


Figure 11. Floating walkway and holding lines.

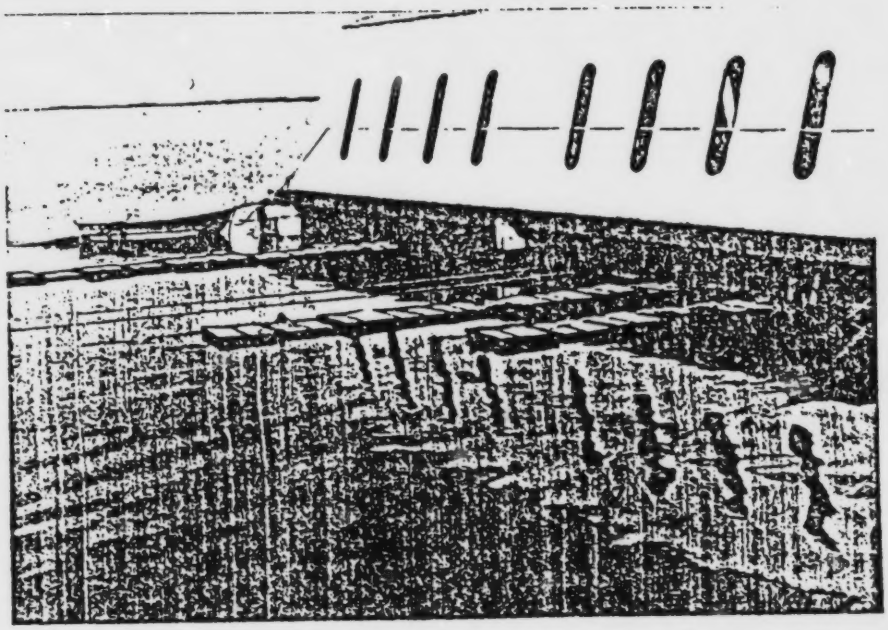


Figure 12. Side view of the floating building.

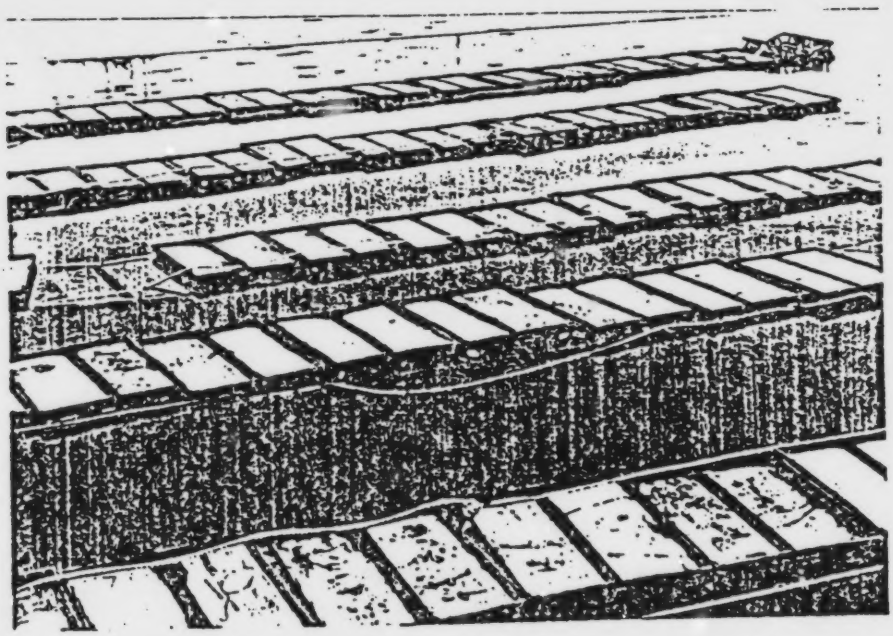


Figure 13. Strings of suspended stacks.

Figure 14. Manoeuvring a stack of lobster trays inside the floating building. At lower right, a movable walkway that serves to facilitate stack unhooking and hooking-on operations.

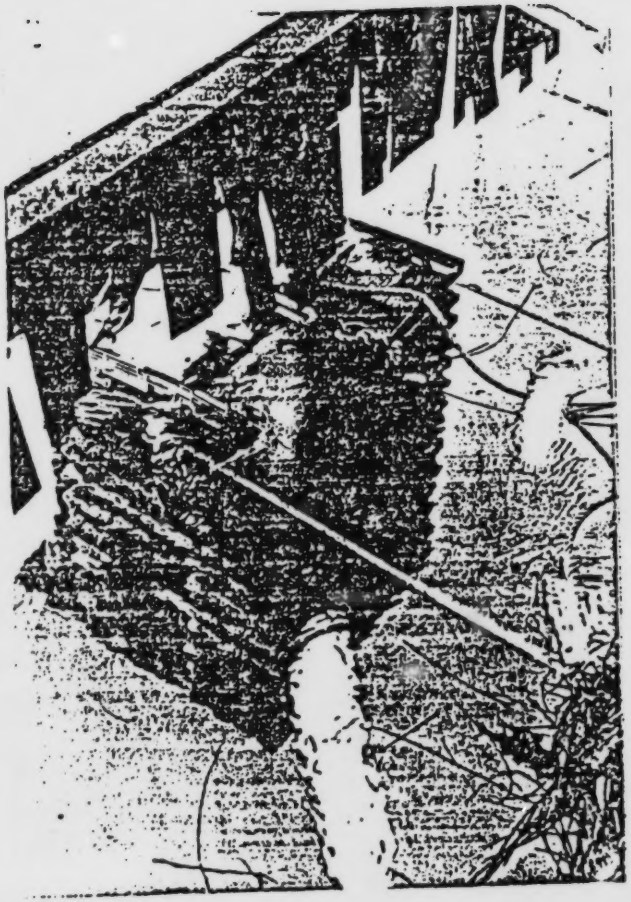


Figure 15. Immersed stack of lobster trays passing under the windbreak and entering the floating building.

more durable metal buckles.

The strap passes through the rigid rings of two snap hooks, one on each side of the top tray in the stack. The openings of these snap hooks face outward. The snap hooks are used to attach the stacks to the holding lines. They also provide a means of sliding the stacks along the lines, and serve as hook-on points when the stack is being lifted (figure 14).

A panel of extruded polystyrene foam 50 mm thick, covered with a piece of 2 cm (3/4") plywood, is placed in the bottom of the topmost tray in the stack. The bottom tray is filled with bricks or pebbles in order to maintain the vertical stability of the stack and hold it at the proper depth. The bottom tray is divided into compartments as a means of preventing it from becoming bent out of shape or damaged by the weight of the other trays during handling operations. The compartments also serve to keep the ballast evenly distributed over the entire surface of the tray. As water is absorbed by the wooden frames inside the trays, the stack floats lower in the water, and the quantity of ballast in the bottom tray is adjusted accordingly as the season advances.

2.2 Floating building

The floating building was designed to provide shelter for the staff of the project, to protect the lobsters against desiccation resulting from wind and heat, and to facilitate lobster feeding and maintenance operations. It is aerodynamic and hydrodynamic in

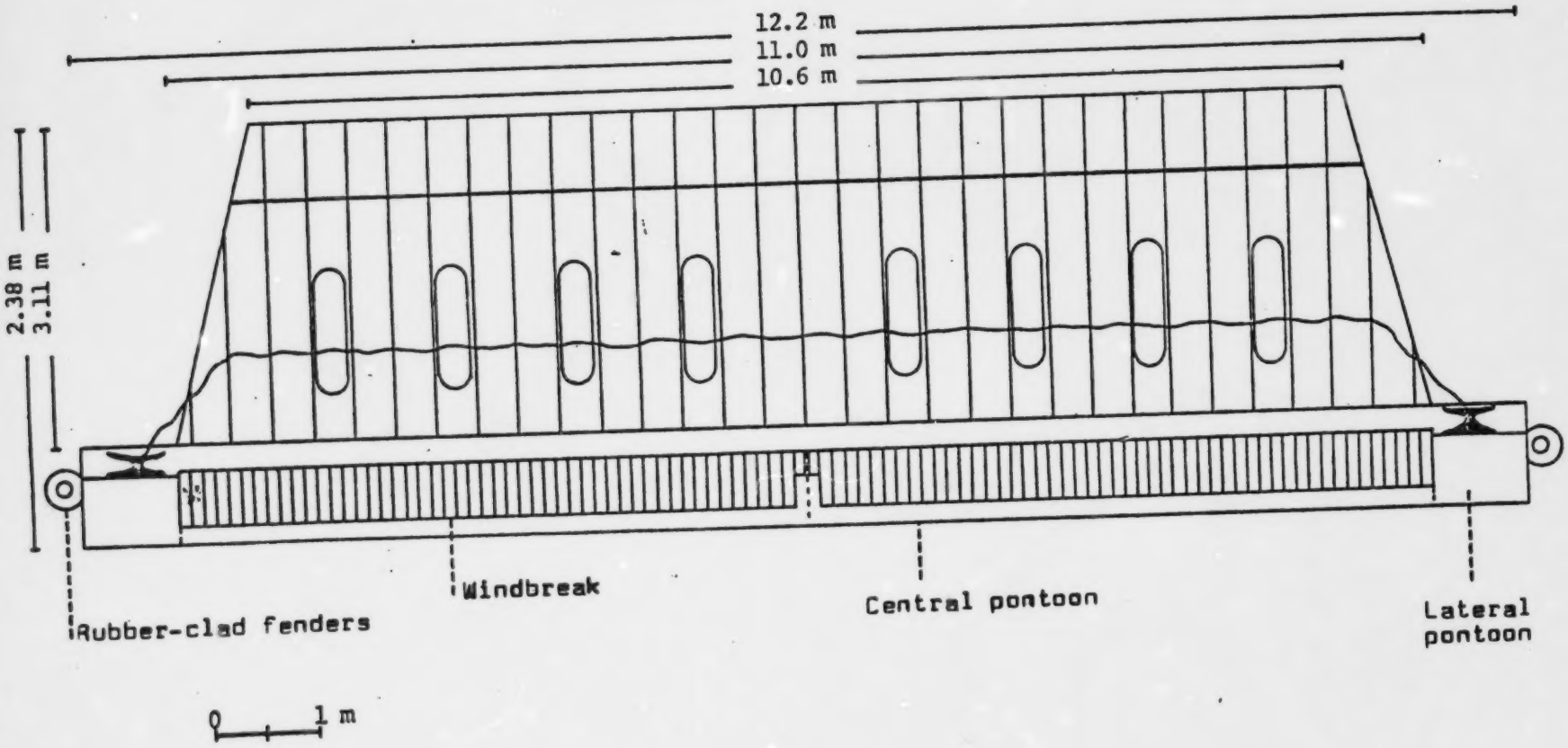


Figure 16. Diagram showing the floating building, side view.

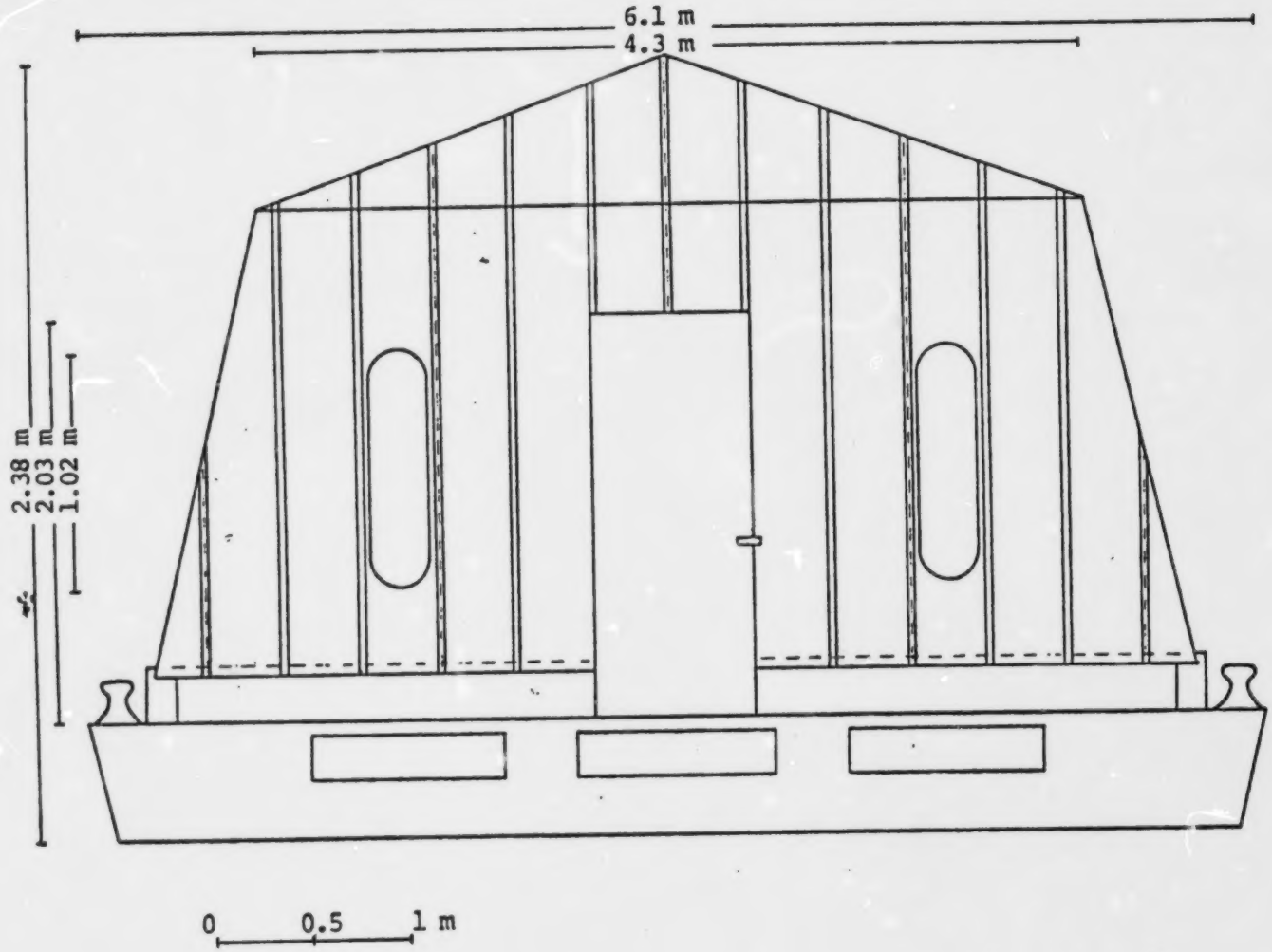


Figure 17. Diagram showing the floating building, front view.

shape (figures 10 and 12), and it is 12.2 m long, 6.1 m wide, and 2.30 m high (figures 16 and 17). It is made of plywood covered inside and out with fibreglass. The advantages of fibreglass are that it facilitates cleaning, thus making satisfactory hygienic conditions easier to maintain, and that it prevents teredos from penetrating the structure.

The building consists of a shelter fixed to a floating base. The slant of the shelter's four walls makes it aerodynamic in shape and increases its stability on the water. An opening at the bottom of each of the side walls provides an entrance through which stacks of lobster trays can be brought inside the building (figures 13, 15 and 16). Windbreaks made of stiff plastic strips are attached to the bottoms of these walls to reduce draughts inside the building. A door at each end of the shelter provides access to the building's interior. Ample light enters through a total of twenty windows. Storage spaces are provided in the attic.

The base of the building consists of a set of three pontoons that keep the structure afloat (figure 18 a): a central pontoon on which feeding operations are carried out, and two lateral pontoons fastened at right angles to the central pontoon, one at each end. These lateral pontoons provide places for boats to come alongside and help to stabilize the building. Fenders were placed on the outer sides of the lateral pontoons (figure 16). The side walls of the pontoons are inclined with a view to reducing water backflow and damping wave action (figure 18 b). Besides providing buoyancy, each compartment can be used for storing lobster trays, spare frames, rope, ballast for the stacks of trays, and the like. The

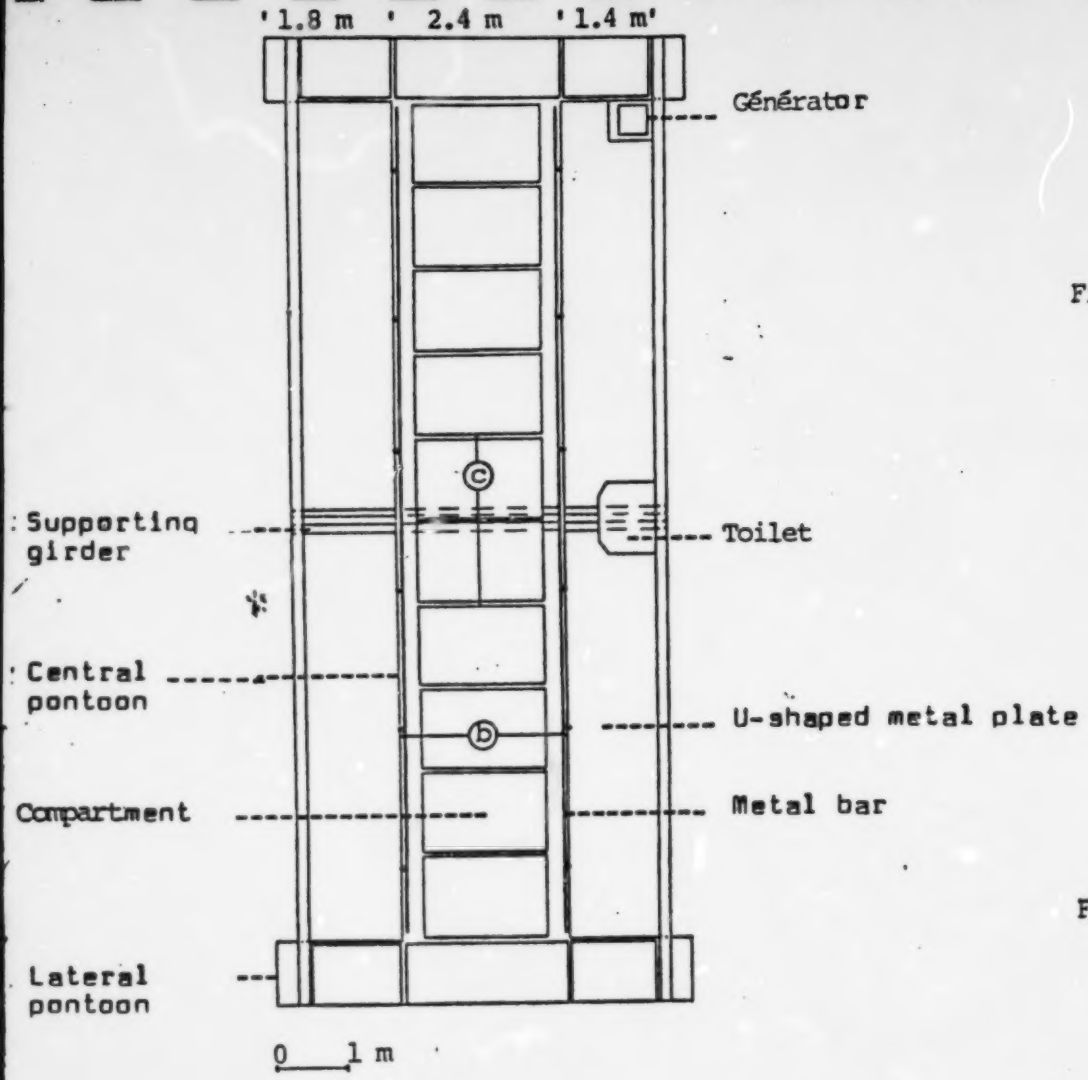


Figure 18. a) Diagram showing the pontoons of the floating building

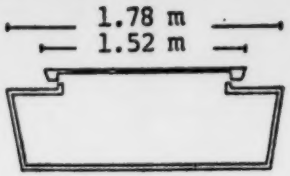


Figure 18. b) Cross-section through the central pontoon.

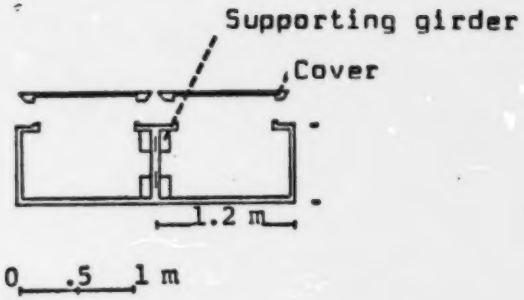


Figure 18. c) Longitudinal section through the central pontoon

interior compartments of the pontoons are accessible via deck panels (figure 18 c). The pontoons could also be used to carry water ballast and to provide wet-well capability; these possibilities, however, were not explored.

2.3 Floating walkways

There are two floating walkways, one on either side of the building. The length of these walkways is the same as that of the building itself. They are made of fibreglass-covered plywood, and floats attached to their undersides provide buoyancy (figure 19). The U-shaped metal plates to which the holding lines are attached are mounted on a metal bar set at surface level.

2.4 Anchoring system

The building and the two floating walkways are anchored by means of steel cables attached to four metal cages resting on the bottom of the lagoon. A diagram of the anchoring system is shown in figure 20. Four metal cables, one attached to each corner of the building, run to the four metal cages. Two cables fastened at the midpoint of each walkway run to two other cables, each of which extends between one end of the walkway and one of the four main corner cables.

2.5 Holding lines

The holding lines are 1.6 cm (5/8") nylon ropes stretched tightly between the central pontoon and the floating walkways. Their function is essentially to keep the suspended floating stacks

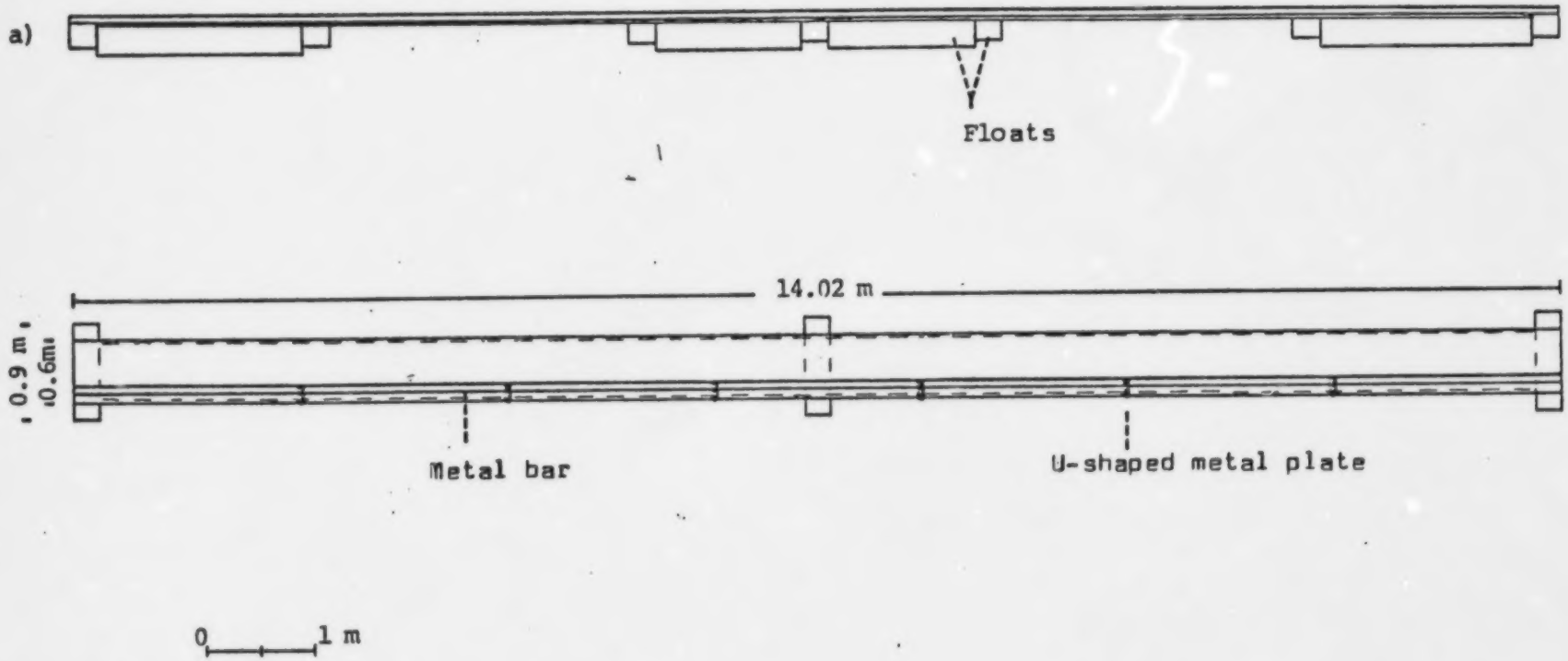


Figure 19. Floating walkway, side view and top view.

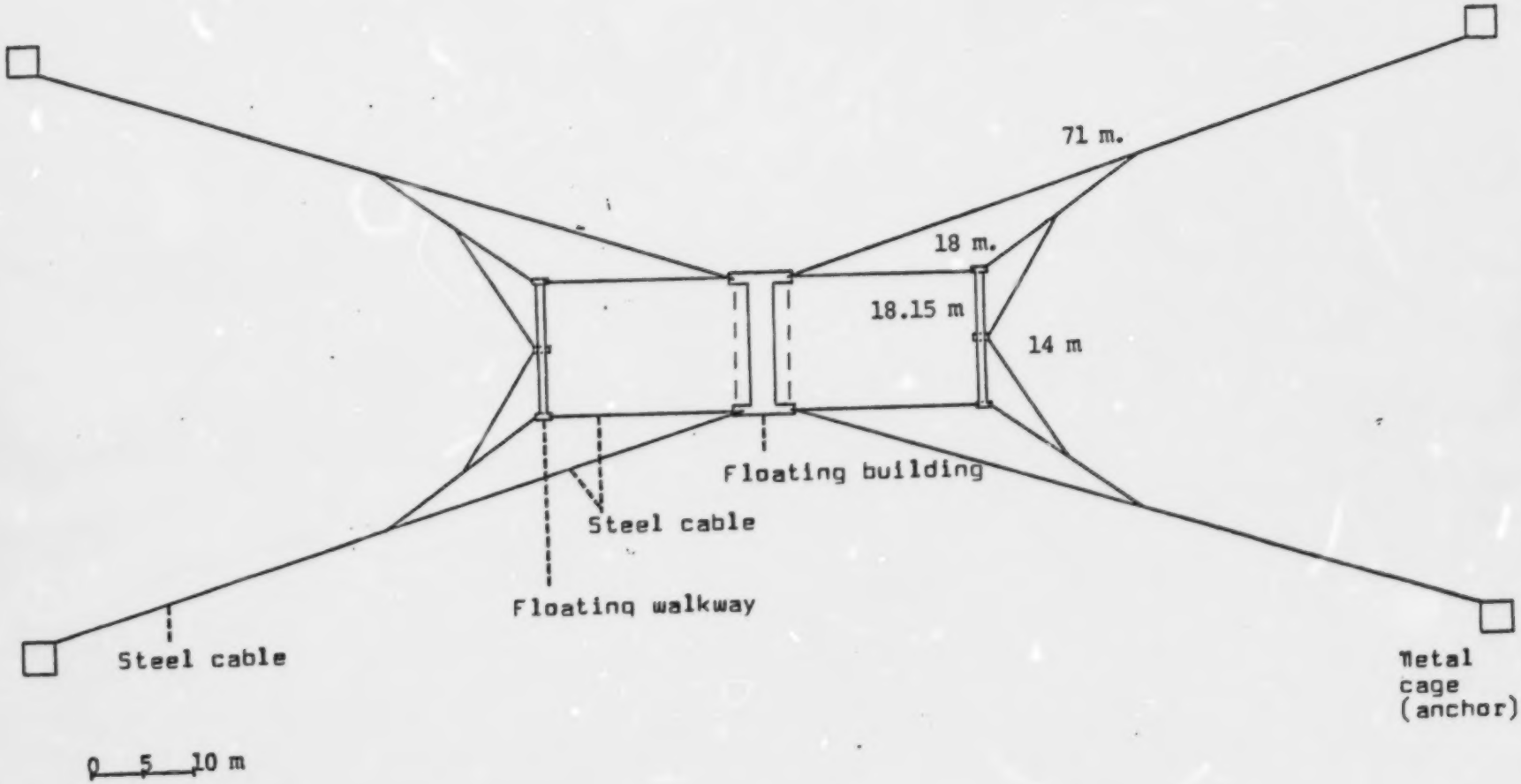


Figure 20. Anchoring system for the floating building and walkways.

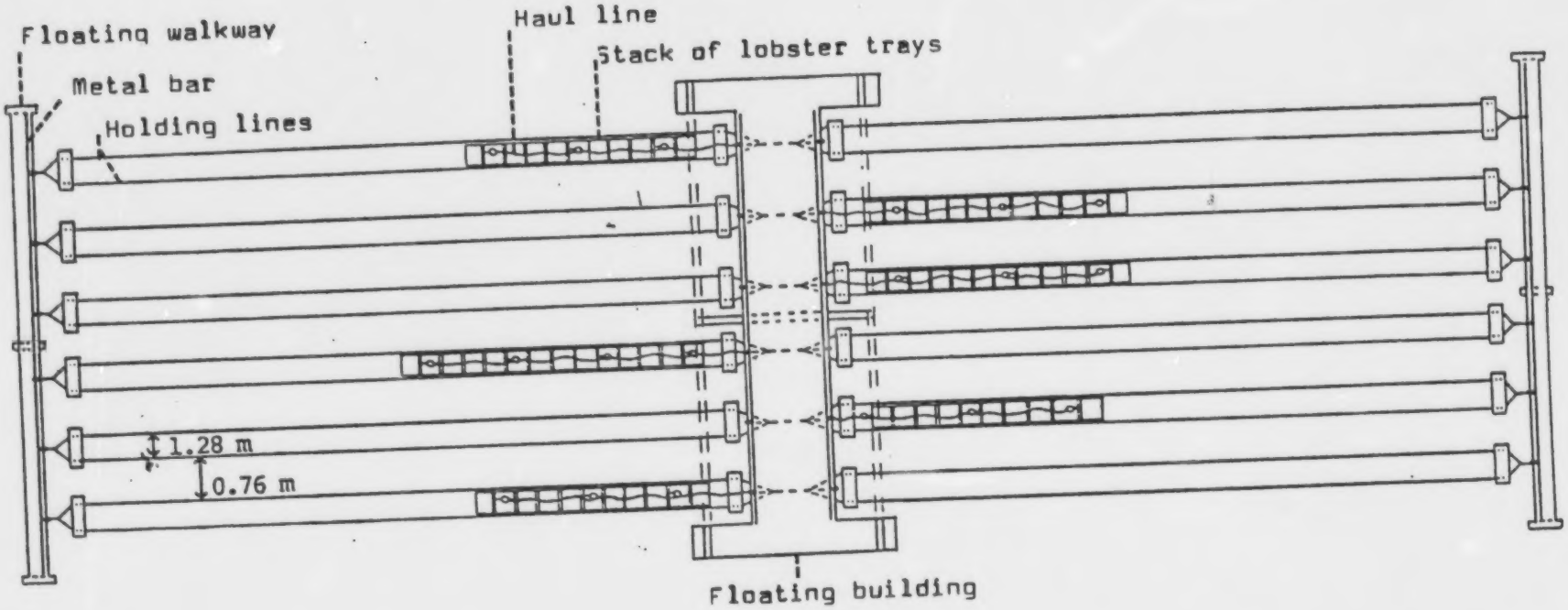


Figure 21. Diagram showing the suspension system used to hold the stacks of lobster trays.

of lobster trays properly aligned. There are six pairs of holding lines on each side of the central pontoon (figure 21).

The end of each holding line runs through a hole in a short board that serves as a spacer between the two lines of a single pair (figure 21). Beyond this point the lines come together to form a Y. They run under the central pontoon and there are made fast to a shackle bolted to a U-shaped metal plate. These U-shaped metal plates, which are mounted on the metal bars fastened to the deck of the central pontoon and to the floating walkways (figure 22 b), provide a means of adjusting the distance between strings of stacks. These various components are permanently installed but require some adjustment during operations.

The spacing between the two lines of each pair is slightly greater than the length of a lobster tray; this facilitates the tasks of raising, lowering and sliding stacks of trays. A minimum of thirty stacks can be strung along each pair of holding lines.

2.6 Haul lines

A haul line consists of a 1.6 cm (5/8") nylon rope with approximately ten snap hooks knotted on to it, and it is used to haul stacks of lobster trays into the building (figure 21). For each string of stacks, a haul line is attached to the outermost stack in the string and to every fourth stack inward. Each snap hook on the haul line is attached to a ring set in the centre of the top tray in the stack (figure 15).

2.7 Stack handling system

An electric winch inside the building is used for handling the stacks of lobster trays (figure 14). The winch is carried on a crab suspended from an overhead crane which can itself travel the length of the building (figure 22 c) on a set of four crabs running along two steel girders fastened to the roof trusses. A stack of lobster trays can thus be moved in any direction inside the building.

The steel cable of the electric winch is fitted with two snap hooks to which the stacks of lobster trays are attached (figure 14). The winch, which has a lifting capacity of 454 kg, runs off a 12-volt battery. An ordinary gasoline-driven DC generator is used to charge the battery; the power of this generator is 2,700 watts.

3. Operation

The frozen food is brought out by boat. After the boat has tied up to the floating building, the feeding operations are carried out inside the building. Figure 23 shows how a stack of lobster trays is moved during feeding. The haul line is used to bring the first stack close in to the central pontoon. One by one the stacks are detached from the holding lines, and from the haul line if necessary, hooked on to the cable of the electric winch, raised out of the water, set on the deck of the central pontoon, and unhooked from the cable. There is room inside the building for a maximum of two rows of ten stacks each at a time. Feeding activities then proceed. The strap holding the trays of

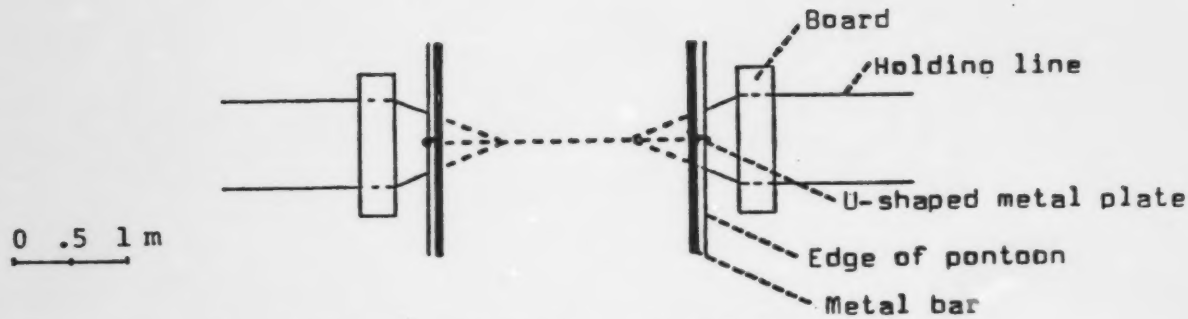


Figure 22. a) Diagram showing how the holding lines are attached to the central pontoon

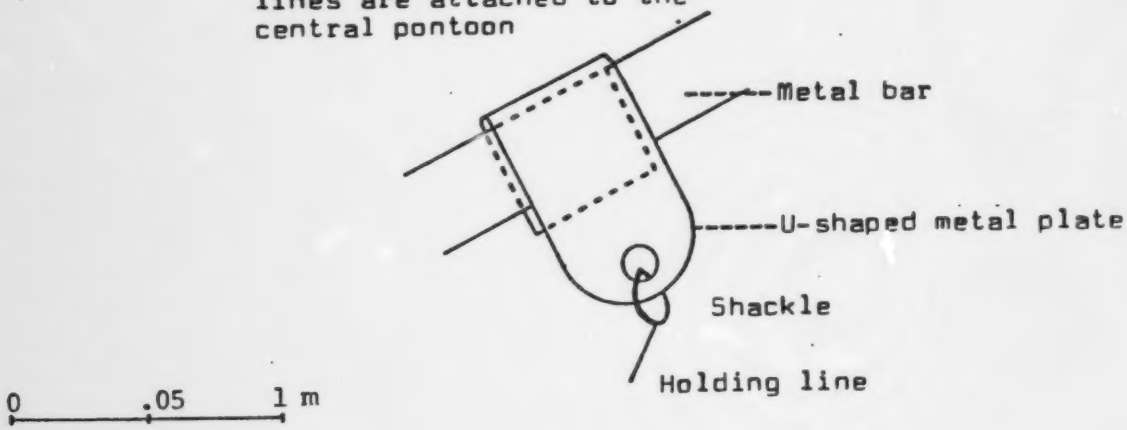


Figure 22. b) Diagram showing how the holding lines are attached to the metal bar

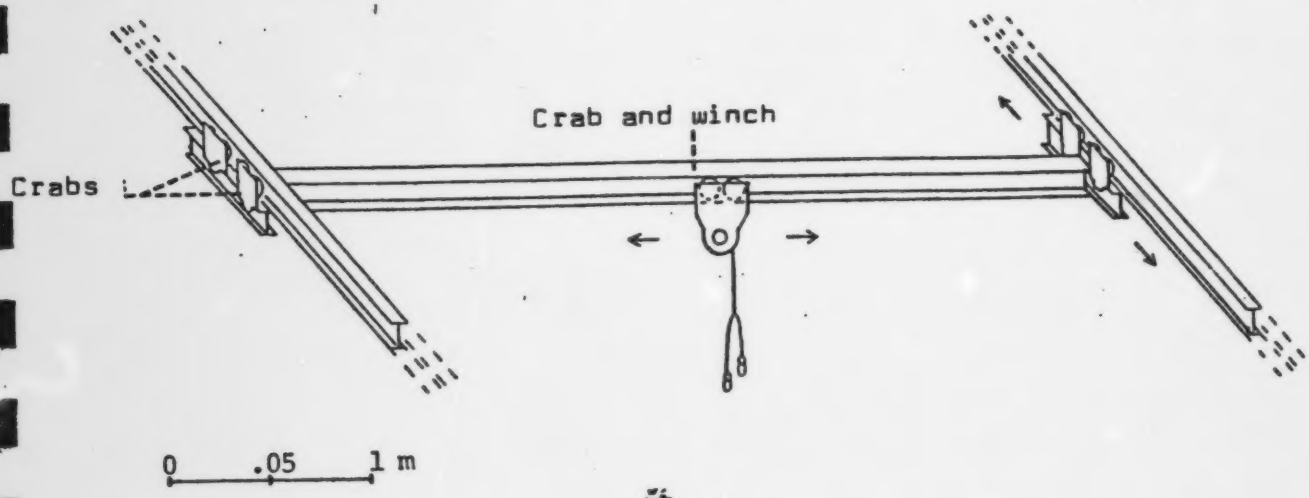


Figure 22. c) Overhead travelling crane and electric winch used to manoeuvre stacks of lobster trays

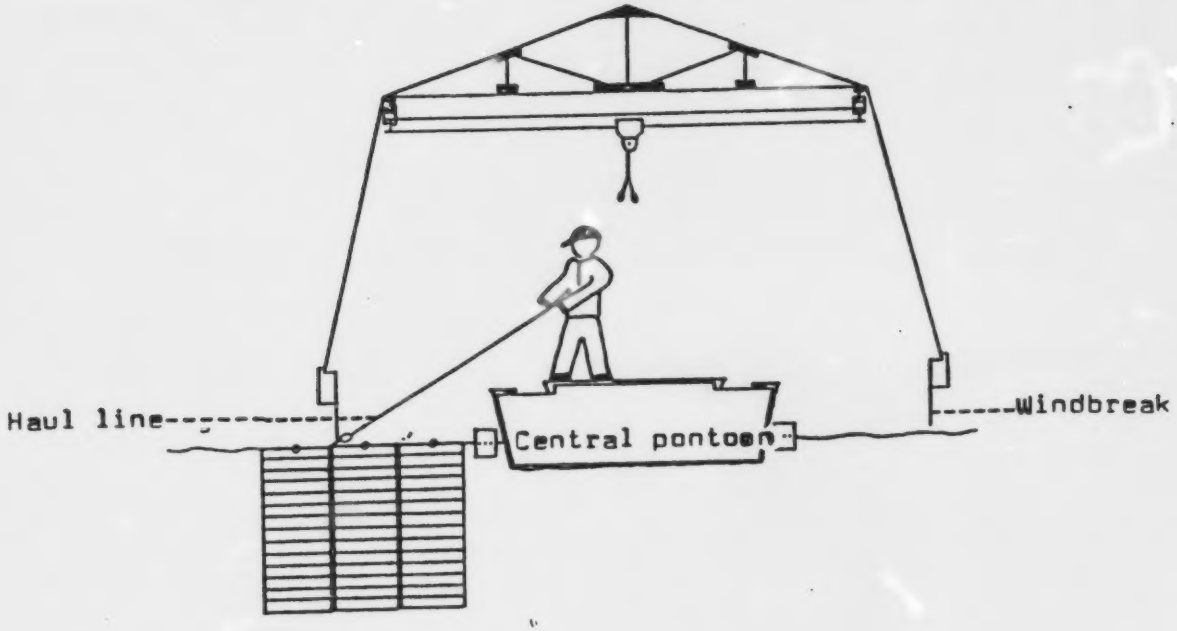


Figure 23. a) Hauling a string of stacks into the building

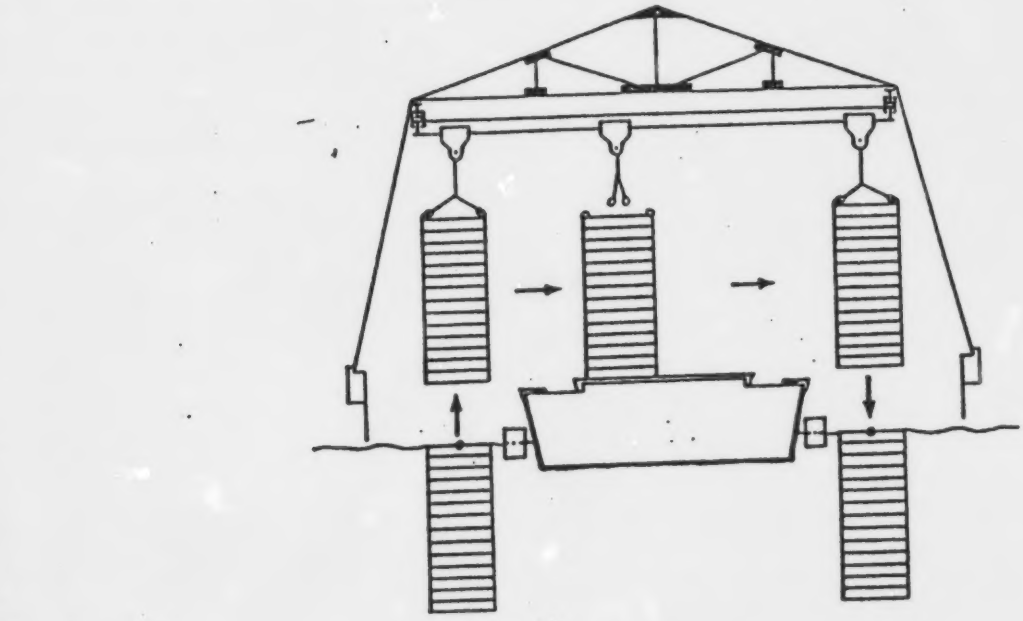


Figure 23. b) Diagram showing successive positions of a stack of lobster trays during feeding operations

the stack firmly together is unbuckled, and feeding begins with the second tray from the bottom, i.e. the lowest tray in the stack that contains lobsters. The trays above this one are tilted backward (figure 24). The food is placed by hand in each of the tray's four compartments, and then the lobsters are inspected and the tray cleaned if necessary. The trays fit together in such a way that when the lobsters in one have been fed, the next tray above can be pivoted downward into a horizontal position and its occupants fed in their turn (figure 24). After all the lobsters in the stack have been fed, the strap is buckled up again and the electric winch is used to place the stack back in the water on the opposite side of the building. Here it is attached as before to the holding lines and, as appropriate, to the haul line. This procedure is used for an entire string of stacks, and then the haul line is made fast to the walkway inside the building. The generator that is used to charge the battery is started up if necessary. Then comes the turn of another string of stacks, and so on. After half a day's work, food residues and such parts of moulted carapaces as have not been eaten are taken ashore.

4. Time required for operations and number of personnel needed

We broke down one day's operations and noted the average length of time required for each of them and the number of personnel needed to perform them. These data enabled us to calculate the number of staff-hours required to run the lobster cultivation system. The data were gathered in November, when the project's staff members were experienced. Their experience, and also the

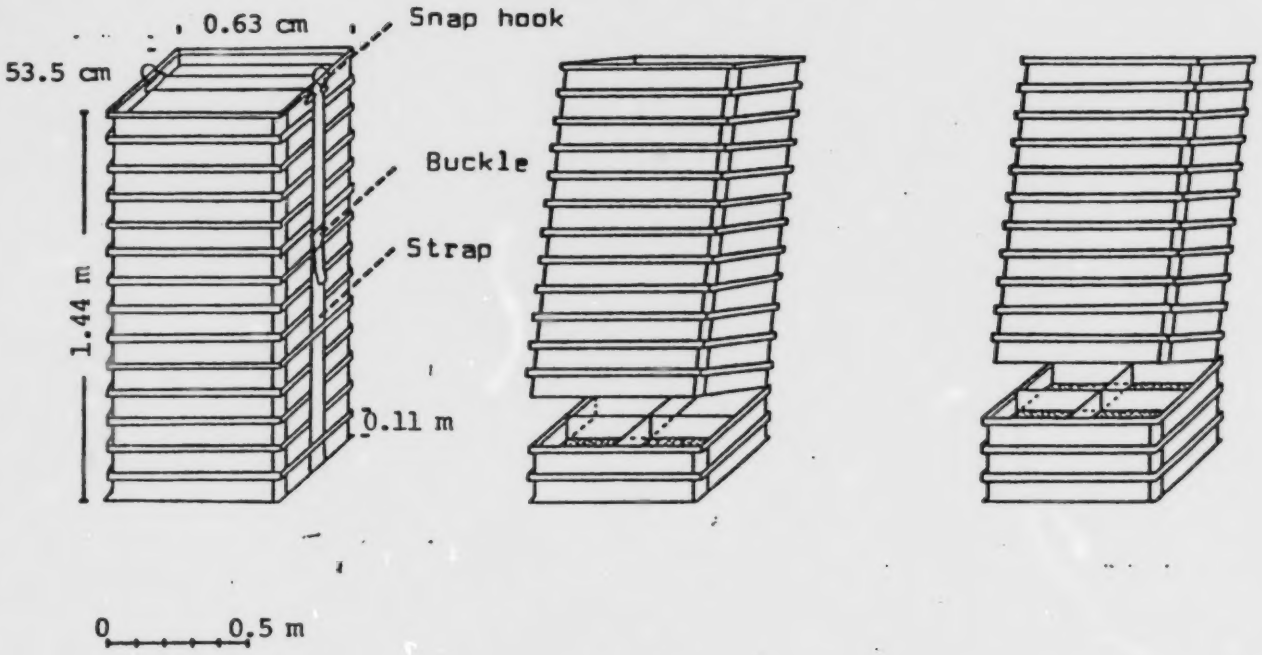


Figure 24. How a stack of lobster trays is tilted for the insertion of food.

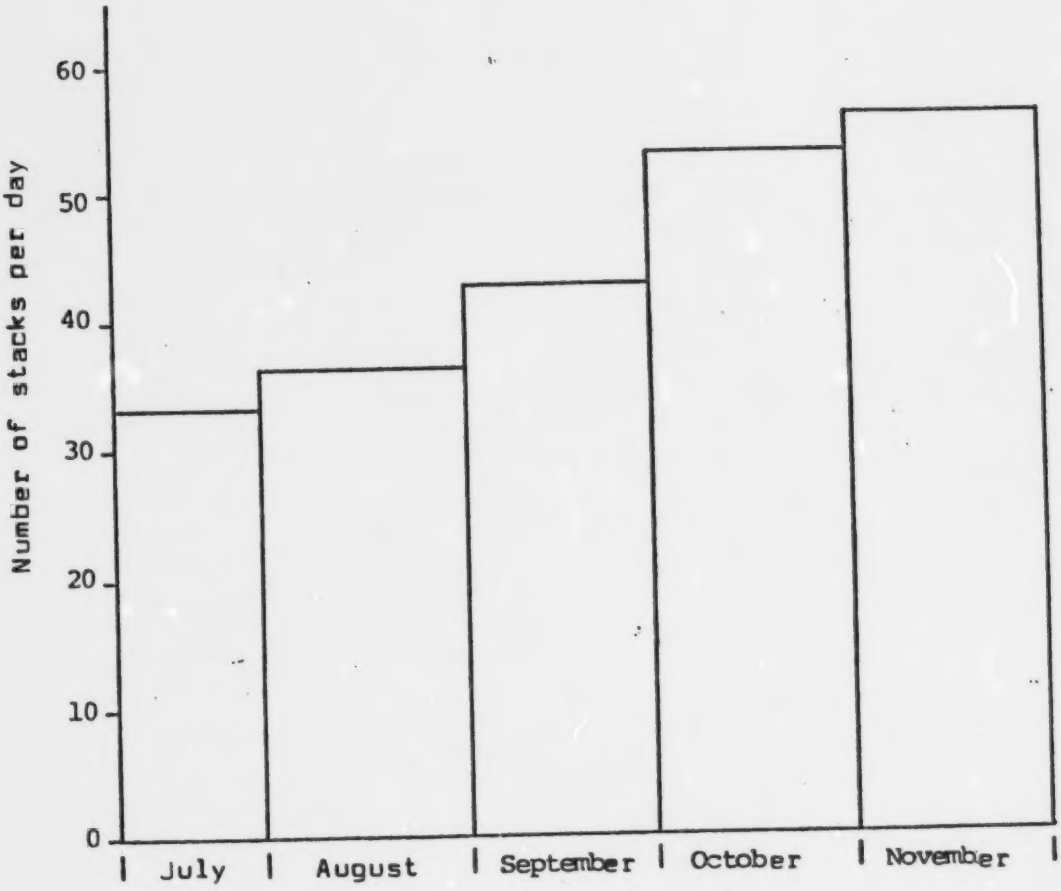


Figure 25 . Seasonal changes in the average number of stacks containing lobsters fed during one day

continual improvement of the technique, probably explains the increase in the numbers of lobsters fed over time (figure 25; the number of lobsters fed is represented by the number of stacks of trays).

Daily operations may be broken down as follows:

- Operation (a): preparation of food. This operation was performed several days before feeding when crab was used to feed the lobsters, and the day of feeding itself when pellets or mussels were used. The crab bodies had to be cut up manually, whereas the pellets were extruded in the desired size and required no special handling. Every day, approximately 2.5 tubs were filled with 100 pounds of crab body quarters; this quantity was adequate to feed 50 stacks of lobsters. Crab legs were also used; these had to be crushed before they were usable as food. From late September onward, mussels picked off the outer surfaces of a lobster tray were immediately put into the same tray.

- Operation (b): preparatory activities ashore. Early in the day and early in the afternoon, the food was transferred from the freezer to the tubs used for transport. When necessary, replacement equipment and other items were carried down to the boat. Gasoline cans were filled regularly for the generator and the boat.

- Operation (c): boat trips. The lobster cultivation project site was located approximately 700 metres from the wharf. The boat travelled this distance four times per day (two return trips). Total trip time includes the time required to warm up the motor and to cast off from and tie up to the floating building. Mechanical problems arose on several occasions, delaying operations.

- Operation (d): preparatory activities on the floating building. This operation consisted of unloading the boat upon its arrival, filling the tank of the generator when necessary, and starting up the generator. Subsequently, the strings of stacks containing lobsters that were to be fed were identified and the movable walkways placed at the stack raising and lowering points. Lastly, the food was transferred to smaller (20-litre) containers.

- Operation (e): raising stacks of trays. A maximum of 20 stacks were hoisted out and placed on the deck of the central pontoon. This operation may be broken down into seven separate manoeuvres:

  (1) reeling out the cable of the electric winch,
  (2) unhooking the stack from the holding lines and hooking it on to the cable of the winch,
  (3) raising the stack out of the water and hauling the next stack in toward the central pontoon; this manoeuvre can be substantially delayed

if the current is too strong,

(4) horizontal transport of the stack and lowering it to the deck,

(5) unhooking the stack from the winch cable,

(6) moving the winch to a point over the next stack to be hoisted out,

(7) unbuckling the strap holding the trays of a stack together.

- Operation (f): feeding and maintenance. The food is placed in the compartments, and residues and uneaten parts of exuviae are removed. Damaged parts are replaced. The stack's ballast is adjusted if necessary.

- Operation (g): reimmersion of stacks. This operation comprises:

(1) replacement and tightening of the strap,

(2) hooking the stack on to the winch cable,

(3) raising the stack and transporting it to a point above the holding lines where it is to go; the time required for this manoeuvre depends on the stack's position on the deck,

(4) lowering the stack into the water,

(5) unhooking the stack from the winch cable and hooking it on to the holding lines. In some instances, attaching the haul line to the ring placed on top of the stack or to the ring set in the central pontoon (after all the stacks of a particular string have been reimmersed),

(6) preparation for the reimmersion of the next stack: the stack that has just been reimmersed is pushed out of the floating building. The time required for this manoeuvre depends on the strength and direction of the current, and sometimes a gaff must be used to push the stack away from the central pontoon where there is no current,

(7) reeling in the winch cable and moving the winch to a point over the next stack to be reimmersed.

- Operation (h): end-of-day tasks afloat. At the end of a day of feeding activities, damaged or other items are loaded into the boat and the building is cleaned.

- Operation (i): end-of-day tasks ashore. Back at the wharf, unused food is put back into the freezer and damaged or other items are taken to the workshop. Waste is taken to the disposal point. Late in the season, at the time of the main lobster marketing period, larger numbers of trays that are no longer required are taken back to the workshop for cleaning and storage.

The time and personnel requirements for each of these operations are shown in table 2. Activities related to the feeding of the lobsters in a single stack (operations e, f and g) take an

Table 2. Time and personnel requirements for the various operations carried out in one day. Data collected in November.

Operation	Time (minutes)	Personnel (number of individuals)	Number of staff-hours
A) Preparation of food			
1) crab bodies	225	1	3.5
2) crab legs	480	1.5	12,0
3) pellets	0	0	0
4) mussels	0	0	0
B) Preparatory activities ashore	25	3	1.25
C) Boat trips	50	3	2.5
D) Preparatory activities on the building	20	3	1.0
E) Raising one stack of lobster trays			
E1	0.28		
E2	0.09		
E3	0.55		
E4	0.20		
E5	0.03		
E6	0.07		
E7	0.32		
E1 to E7	1.54	3	0.08
F) Feeding and maintenance of the lobsters in one stack	1.54	3	0.08
G) Reimmersion of one stack			
G1	0.21		
G2	0.13		
G3	0.29		
G4	0.32		
G5	0.16		
G6	0.22		
G7	0.31		
G1 to G7	1.64	3	0.08
H) End-of-day tasks afloat	15	5	0.75
I) End-of-day tasks ashore	10	3	0.50
Operation B, C, D, H, J,	120	3	6
Operation E, F, G,	4.7	3	0.24

average of 4.7 minutes with the handling system used and require a crew of three persons. The other operations and trips (operations b, c, d, h and i) require a total of 120 minutes, i.e. six staff-hours.

5. Capacity of the system

During an eight-hour working day, two fifteen-minute periods are set aside for breaks and 120 minutes are allocated for activities other than actual feeding. A total of 330 minutes are thus devoted to feeding operations. In view of the fact that the time required to feed the lobsters in one stack is 4.7 minutes, a maximum of 70 stacks of lobsters can be fed daily. Table 3 shows the capacity of the system for various feeding schedules. As will be seen, the lower the frequency of feeding, the more lobsters can be fed in a week. In order for lobsters in their post-moult period to be adequately nourished, they should be fed four times per week, according to Fradette (1984 b); the capacity of the system during that period is thus 4,200 specimens. In contrast, a frequency of twice a week is adequate to maintain lobsters that will not moult during their captivity, and accordingly the number of specimens that can be kept increases to 8,400. Thus in order to use a lobster cultivation system to best advantage, it is most important to be able to predict moulting. The capacity values shown in table 3 are valid given the handling system used and a work crew of three.

Table 3. Capacity of handling system used for feeding operations.

Frequency of feeding (number of times per week)	Capacity of system	
	Number of stacks	Number of lobste
5	70	3 360
4	87.5	4 200
2.5	140	6 720
2	175	8 400

BIOLOGICAL FOLLOW-UP

1. Changes in the number of lobsters being kept

Figure 26 shows how the number of lobsters being kept changed over the season. The initial increase is attributable to the stocking of the project facility, and the subsequent decline was due to sales, mortality, losses, and the killing of lobsters for experimental purposes. At the end of the project we sank some lobsters in their trays to the bottom of the lagoon, to spend the winter under the ice.

2. Losses and their causes

Losses from factors other than mortality amounted to 4.3‰. Eighty-one per cent of these losses are attributable to defects in the lobster tray attachment system. Three per cent of the losses resulted from theft at the point of sale and from errors during handling, 16‰ of which occurred during transport of the floating building when it was laid up in December.

3. Mortality

Of the 6,749 lobsters kept, 2.64‰ died during the project. Sixty-seven per cent of the dead lobsters were removed early in the project, between mid-June and mid-August. In order to keep track of seasonal variations in mortality we calculated the daily mortality rate (Mi) by means of equation (1) below:

$$Mi(\%) \quad \frac{Ai \times 100}{(Ni - Pi)\, Ti} \qquad (1)$$

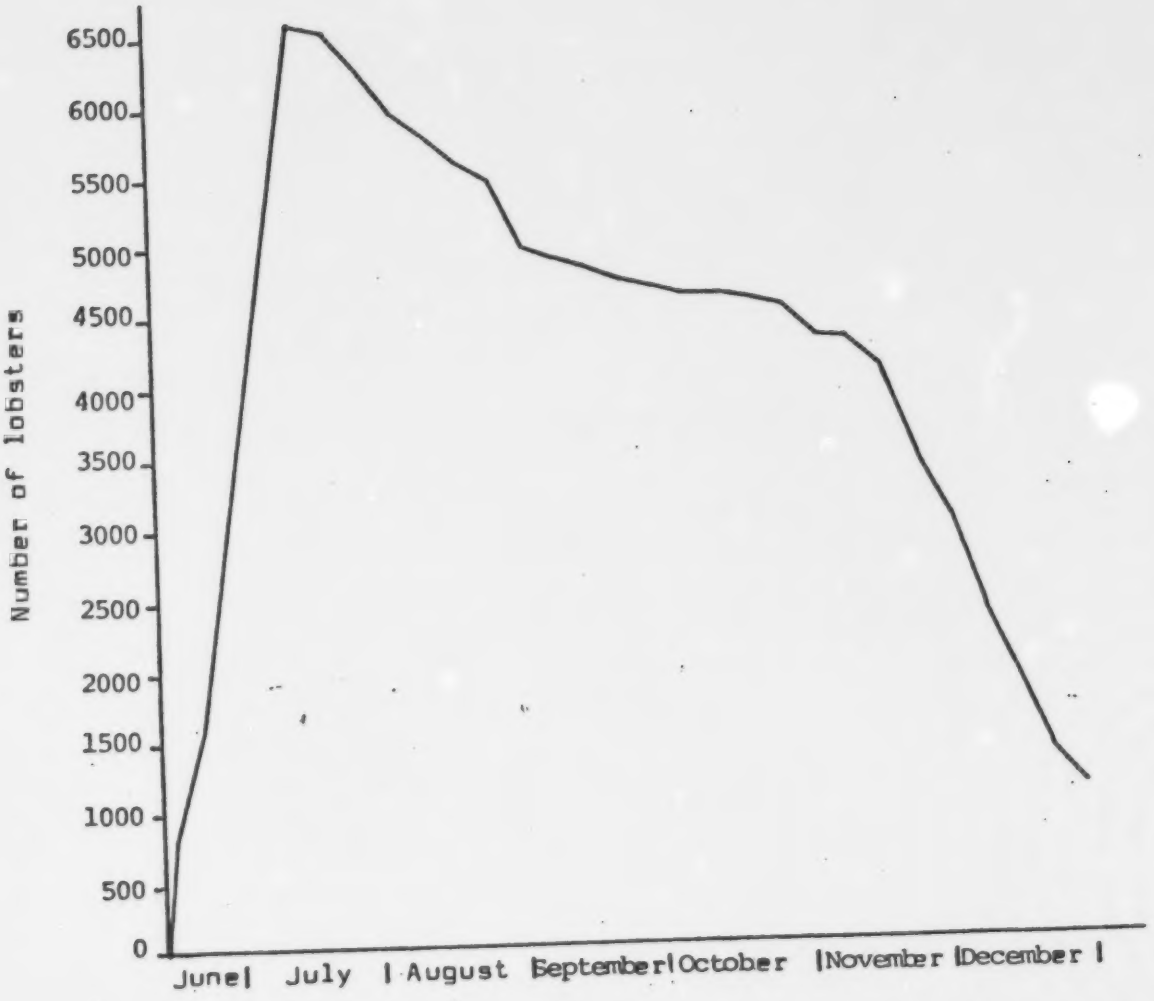


Figure 26. Change over time in numbers of lobsters being kept in 1984.

in which Ai = number of lobsters that died during period i,

Ni = number of live lobsters at the beginning of period i,

Pi = number of lobsters lost, killed for experimental purposes and sold during period i,

Ti = length of period i (in days), the ordinary value of Ti being seven days.

This rate increased from 0.02% to a maximum of 0.09% during the first week following the stocking phase (figure 27 b). It declined progressively thereafter, and from early October to the end of the project did not exceed 0.01% at any time. We also calculated the mortality rate among lobsters in the experimental group (figure 27 a). The graph shows two peaks in mortality among lobsters in this group; these peaks are discernible for the total population of the project facility as well, but they are less clear-cut (figures 27 a and b).

4. Autopsies

Whenever a lobster died, the stage it had reached in its moulting cycle was determined. It appeared that for the period June 15-August 1, 7% of all lobsters that died had moulted, whereas from early August to the end of the project the ratio of moulters to non-moulters was 1:1.

Bacteriological tests were carried out on nine lobsters that had died. The bacterium Aerococcus viridans (var.) homari was not detected in the case of any of these, and thus the mortality that occurred was evidently not caused by gaffkemia. External examination of fifteen dead lobsters, however, revealed serious

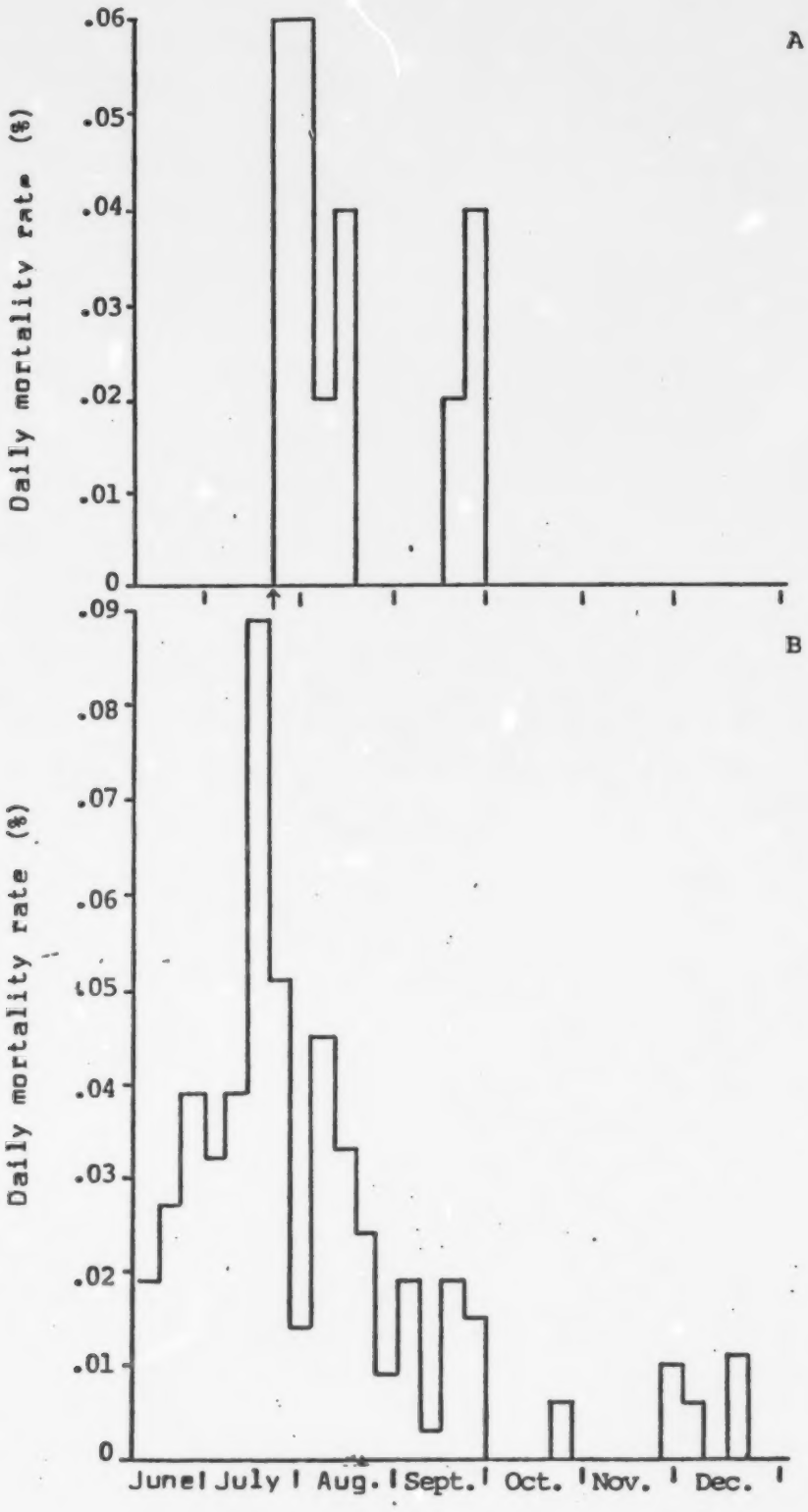


Figure 27 . Seasonal change in the daily mortality rate among (a) lobsters in the experimental group and (b) all lobsters in the project.
(↑ : formation of the experimental gro

injuries that could have resulted in death from loss of blood.

5. Growth

5.1 Moulting periods and frequency of moulting

By examining the daily moulting rate (Mo_i) defined by equation (2) below, we were able to identify two moulting periods both for lobsters in the experimental group and for all the lobsters kept in the project facility (figure 28 a and b).

$$Mo_i\ (\%) \qquad \frac{Ai \times 100}{Ni \times Ti} \qquad (2)$$

in which Ai = number of lobsters moulting during period i,

Ni = number of live lobsters at the beginning of period i,

Ti = duration, in days, of period i.

The first moulting period began early in July and continued until mid-September, with maximum moulting intensity being reached late in July. The other period extended from mid-September to mid-December. The intensity peak for this second moulting period occurred early in October. We kept track of the numbers of lobsters in the experimental group that moulted in the two periods, and found that approximately 50% of the total moulted in each. However, the lobsters constituting the experimental group were selected at the end of the stocking phase, at a time when they were between moults, whereas some of the other lobsters in the project facility had already begun to moult by then, and it follows that our findings regarding the percentage of first-period moulters are a slight underestimate. The total percentage of moulters,

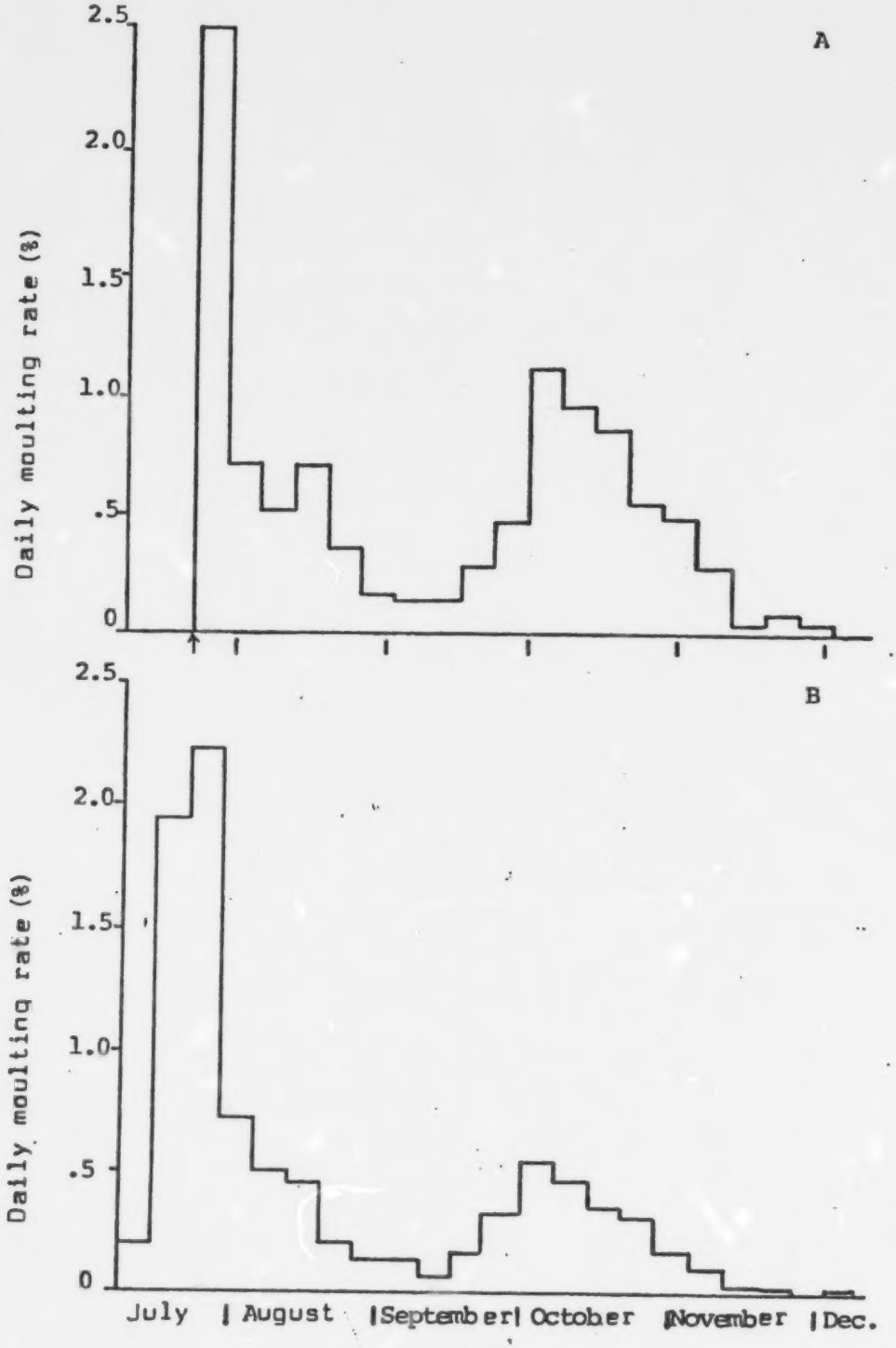


Figure 28 .Changes in the daily moulting rate among
(a) lobsters in the experimental group and
(b) all lobsters in the project.
(↑: formation of the experimental group)

counting both moulting periods, was 71%; none of the lobsters moulted twice. This figure would be slightly higher if we had been able to include data from the beginning of the project. For the population under cultivation as a whole, 78% of the lobsters that moulted did so during the first moulting period. The fact that there were more moulters in the first period is attributable to the marketing during that period of lobsters in their pre-moult phase which would presumably have moulted during the second moulting period.

5.2 Changes over time in hardness of the carapace

After a lobster moults, the new carapace is soft at first, but as it becomes progressively calcified it grows increasingly hard. The various parts of the carapace harden in a specific order (figure 9). The dorsocephalic region is the first to become calcified, followed by the dorsothoracic region and then the lateral part of the cephalothorax. One or more possible stages of the moulting cycle are associated with the state of hardness of the carapace (figure 9). We determined what stage in their moulting cycle the lobsters in the experimental group had reached on three separate occasions during the season (figure 29). By following up these specimens we were able to calculate, for moulters, the number of days between moulting and determination of the moulting cycle stage. It appears that non-moulters were at stage C4 or D in their moulting cycle, regardless of the period considered. The proportion of lobsters that had remained at or reached stage C4 or D was 63.0% in October and 71% in December. By the end of the project, 29% of all moulters were still at development stage C1, C2 or C3. It will be noted that only specimens at stage C4 or D in their moulting cycle have hard

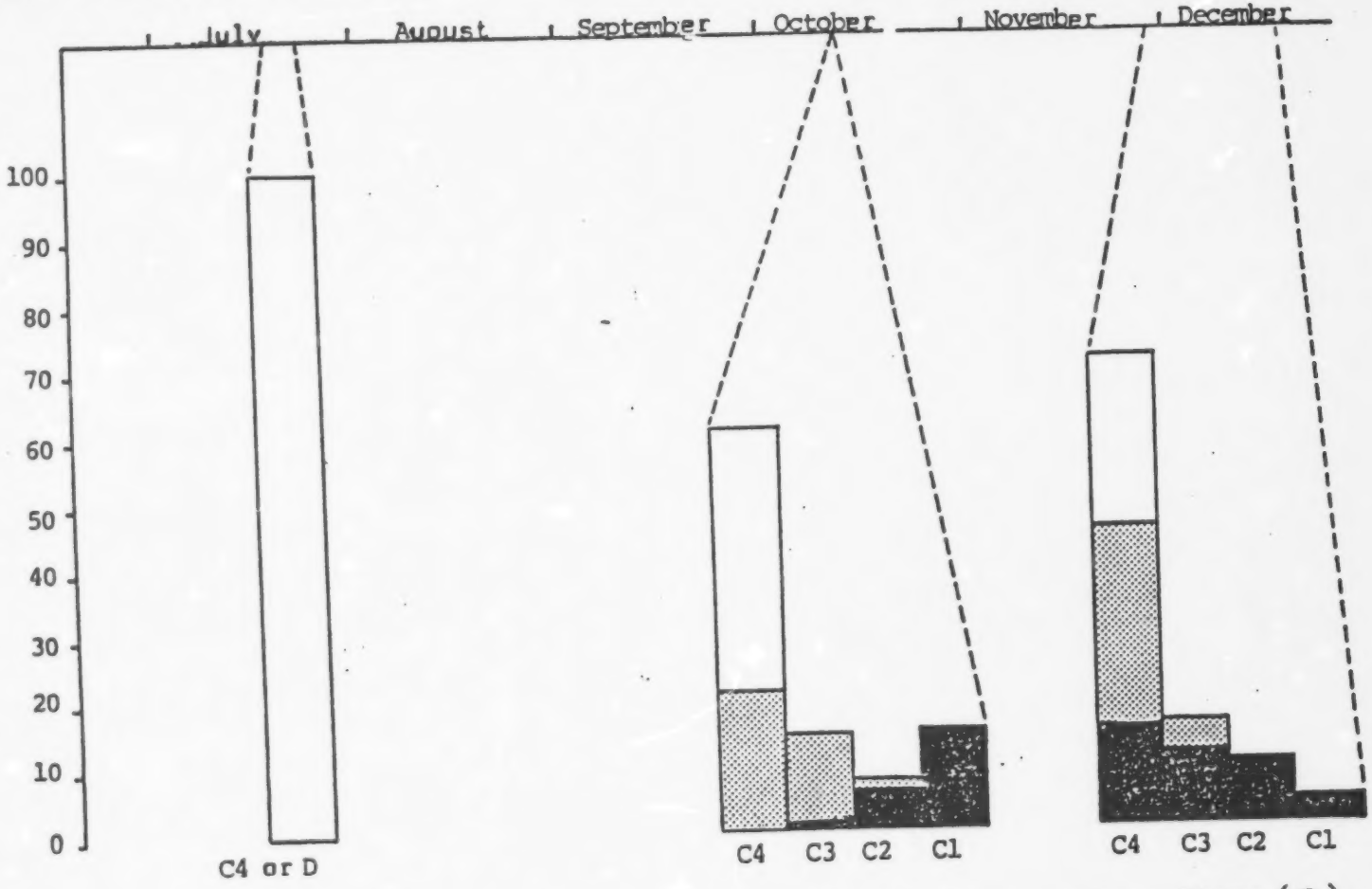


Figure 29. Changes over time in moulting cycle stage among non-moulters (□), first-period moulters (▨), and second-period moulters (■) in the experimental group.

Table 4. Weight gains attained by specimens in the experimental group ($\bar{x}$ = average; n = number of specimens); W = initial weight; WG1 = percentage weight gain exclusive of lobsters with a claw missing, and WG2 = percentage weight gain including lobsters with a claw missing.

	$\bar{x}$ W (s) (n)		$\bar{x}$ WG1 (s) (n)		$\bar{x}$ WG2 (s) (n)	
Both moulting periods (days 190 to 343)	399.8	(52.1) (169)	36.3	(8.9) (164)	35.8	(9.3) (169)
First moulting period (days 190 to 254)	409.0	(60.2) (77)	39.6	(60.2) (75)	39.2	(7.5) (77)
Second moulting period (days 255 to 343)	391.4	(42.7) (92)	33.4	(9.2) (89)	33.0	(9.8) (92)
Non-moulters	425.7	(69.7) (59)	1.7	(2.2) (59)	1.7	(2.2) (59)

carapaces.

5.3 Weight gains among moulters and non-moulters

Data on growth in weight are shown in table 4. The average initial weight of non-moulters was 426 grams, and their average weight gain was 1.7%. The average initial weight of the moulters of both periods (400 grams) was less than that of the non-moulters, while the average initial weight of first-period moulters was nine grams greater than that of second-period moulters. For both moulting periods combined, the weight gain was 36.8%, excluding specimens that had lost a claw, and 35% for all the lobsters in the experimental group. Comparison of average weight gains for the first and second moulting periods reveals that the former was 6.2% greater than the latter.

5.4 Changes over time in meat yield

Data on wet and dry meat yields are shown in table 5. For all categories of lobsters kept in the course of the project, yields were below the standard established in 1983 by Fradette (1984 b). Meat yields from moulters were lower than those from non-moulters, and of the former, yields from second-period moulters were lower than those from first-period moulters. However, while total meat yields from first-period moulters were greater than those from second-period moulters, the average yield of tail meat was greater in the case of the latter (table 5). Figures 30 and 31 show the seasonal changes in total meat yields and in yields of claw meat and tail meat separately. As will be seen, from mid-October to late November, wet claw meat yields from non-moulters and first-period moulters increased, while tail meat yields

Table 5. Wet and dry meat yields from non-moulters, first-period moulters and second-period moulters at the end of the lobster cultivation project. Standard data obtained from specimens caught late in the 1983 lobster-catching season.

Category	Live weight	Meat yield									
		Wet					Dry				
		Claws		Tail	Claws & tail		Claws		Tail	Claws & tail	
		Cutting	Crushing				Cutting	Crushing			
	$\bar{x}$ (s) (n)	$\bar{x}$ (s) (n)	$\bar{x}$ (s) (n)	$\bar{x}$ (s) (n)	$\bar{x}$ (s) (n)		$\bar{x}$ (s) (n)	$\bar{x}$ (s) (n)	$\bar{x}$ (s) (n)	$\bar{x}$ (s) (n)	
Non-moulters	426.7 (68.9) (10)	5.4 (0.4) (10)	7.2 (0.9) (10)	11.3 (1.3) (10)	23.8 (2.0) (10)		1.3 (0.1) (10)	1.7 (0.2) (10)	3.0 (10)	6.0 (0.5) (10)	
1st-period moulters	542.2 (45.6) (10)	4.3 (0.5) (10)	7.0 (0.9) (10)	8.9 (1.4) (10)	20.0 (2.4) (10)		1.0 (0.2) (10)	1.6 (0.2) (10)	2.1 (0.4) (10)	4.7 (0.6) (10)	
2nd-period moulters	509.5 (65.4) (10)	3.5 (0.5) (10)	4.2 (0.8) (10)	9.4 (1.1) (10)	17.1 (2.1) (10)		0.7 (0.1) (10)	0.8 (0.1) (10)	2.3 (0.2) (10)	3.9 (0.3) (10)	
Standard based on commercially caught specimens											
Canner	380 (28) (10)	5.7 (?) (25)	7.8 (?) (25)	12.2 (1.0) (10)	25.7 (4.6) (10)		1.4 (?) (25)	1.9 (?) (25)	3.4 (0.4) (10)	6.7 (0.9) (10)	
Market	498 (42) (10)	6.5 (?) (10)	8.5 (?) (10)	11.6 (1.3) (10)	26.5 (3.3) (10)		1.7 (?) (10)	2.1 (?) (10)	3.4 (0.4) (10)	7.2 (1.0) (10)	

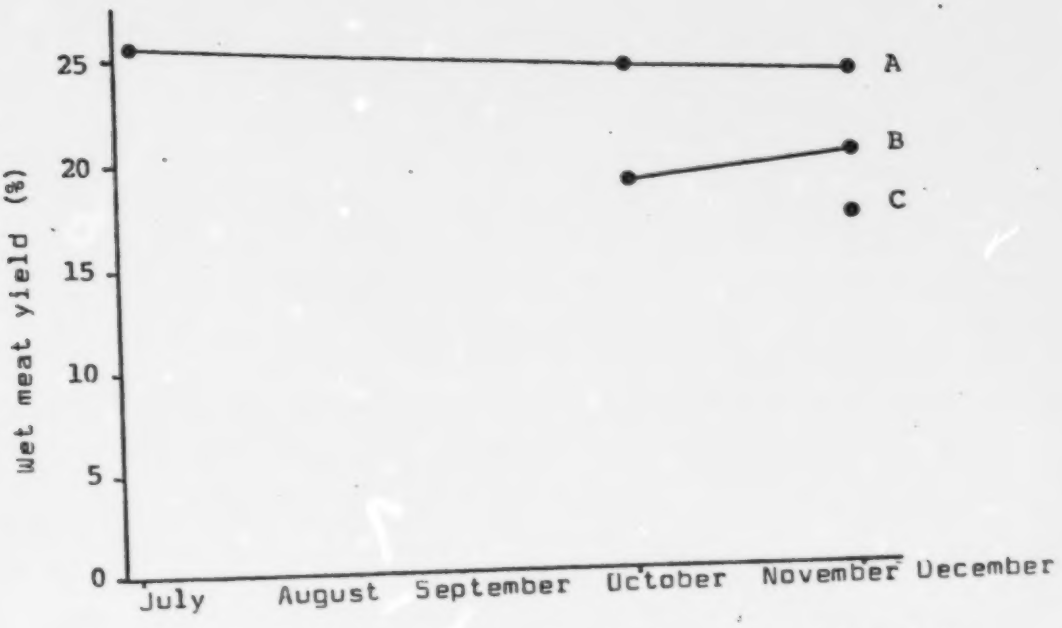


Figure 30. a) Seasonal change in meat yields from (a) non-moulters, (b) first-period moulters and (c) second-period moulters.

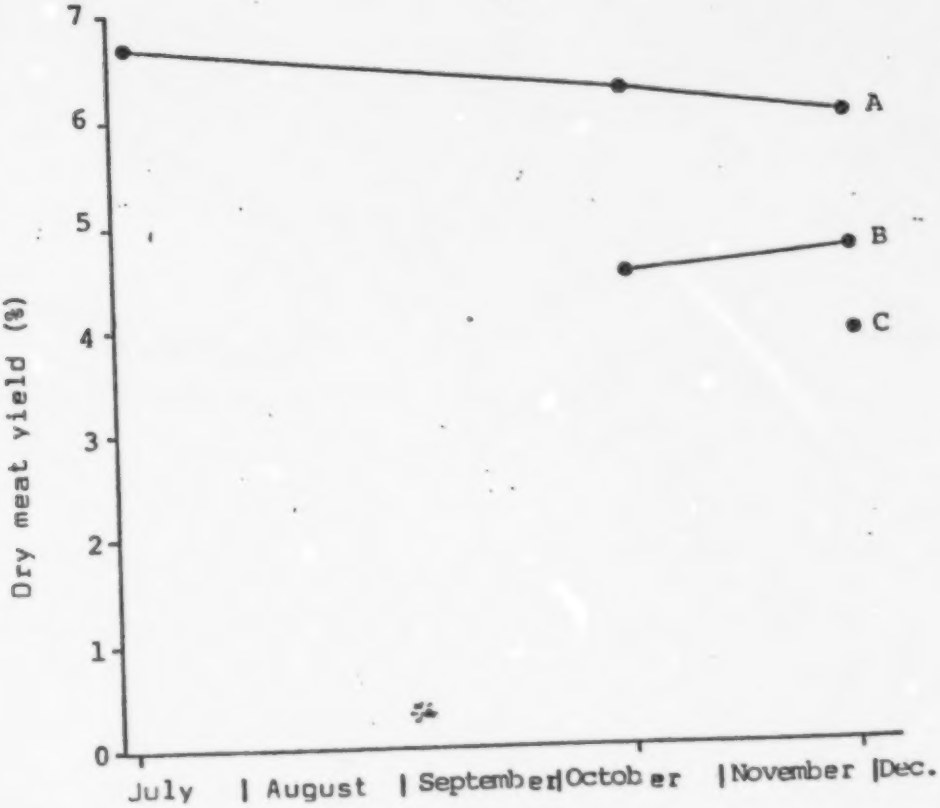


Figure 30. b) Seasonal change in dry meat yields from (a) non-moulters, (b) first-period moulters and (c) second-period moulters.

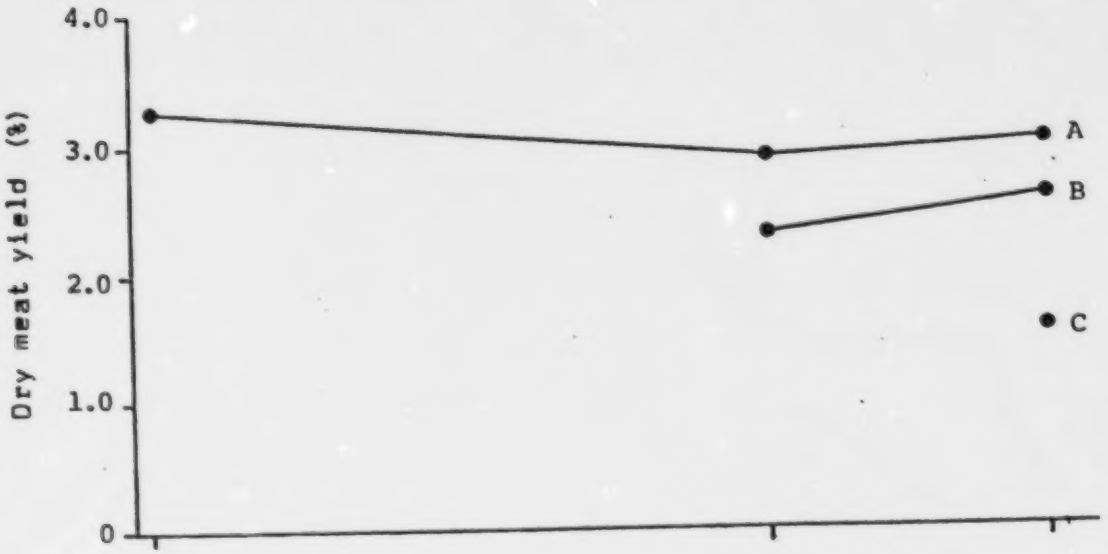


Figure 31. a) Seasonal change in dry claw meat yields from (a) non-moulters, (b) first-period moulters and (c) second-period moulters.

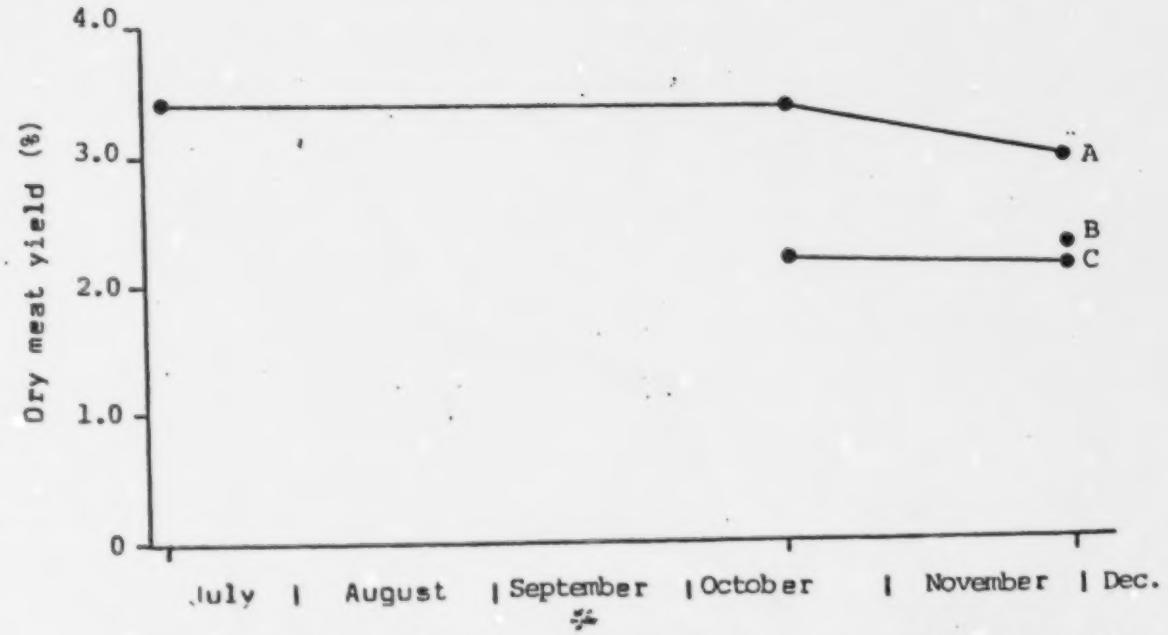


Figure 31. b) Seasonal change in dry tail meat yields from (a) non-moulters, (b) first-period moulters and (c) second-period moulters.

declined in the case of the non-moulters and remained substantially the same in the case of the first-period moulters. In the case of first-period moulters, comparison of the figures for the two claws reveals that the meat yield from the crushing claw at the end of the project was closer to the values observed for the standard group than the meat yield from the cutting claw. The opposite phenomenon is found for second-period moulters. These observations indicate that it is primarily the crushing claw that responds to the fattening process.

Overall, a clear-cut difference is observable between meat yields from cultivated lobsters and those from lobsters in the standard group. Among moulters, the degree of fattening depends on the stage in the moulting cycle.

5.5 Blood protein levels

Among non-moulters, the blood serum protein level was substantially the same in October (49.5 mg/l) as in late November (48.5 mg/l). After a lobster has moulted, its blood serum protein level declines, subsequently increasing gradually; in the case of our specimens, a mean value of 36 mg/l was reached 124 days after moulting (figure 32). Thus by the end of the project even those lobsters that had moulted earliest had not attained the same degree of nourishment as those that had not moulted at all.

6. Loss of claws and other injuries

Out of all the lobsters kept under the project (n: 6,749 specimens), 1.3% lost at least one claw. For the experimental group (n: 240 specimens), the corresponding percentage was 0.8%.

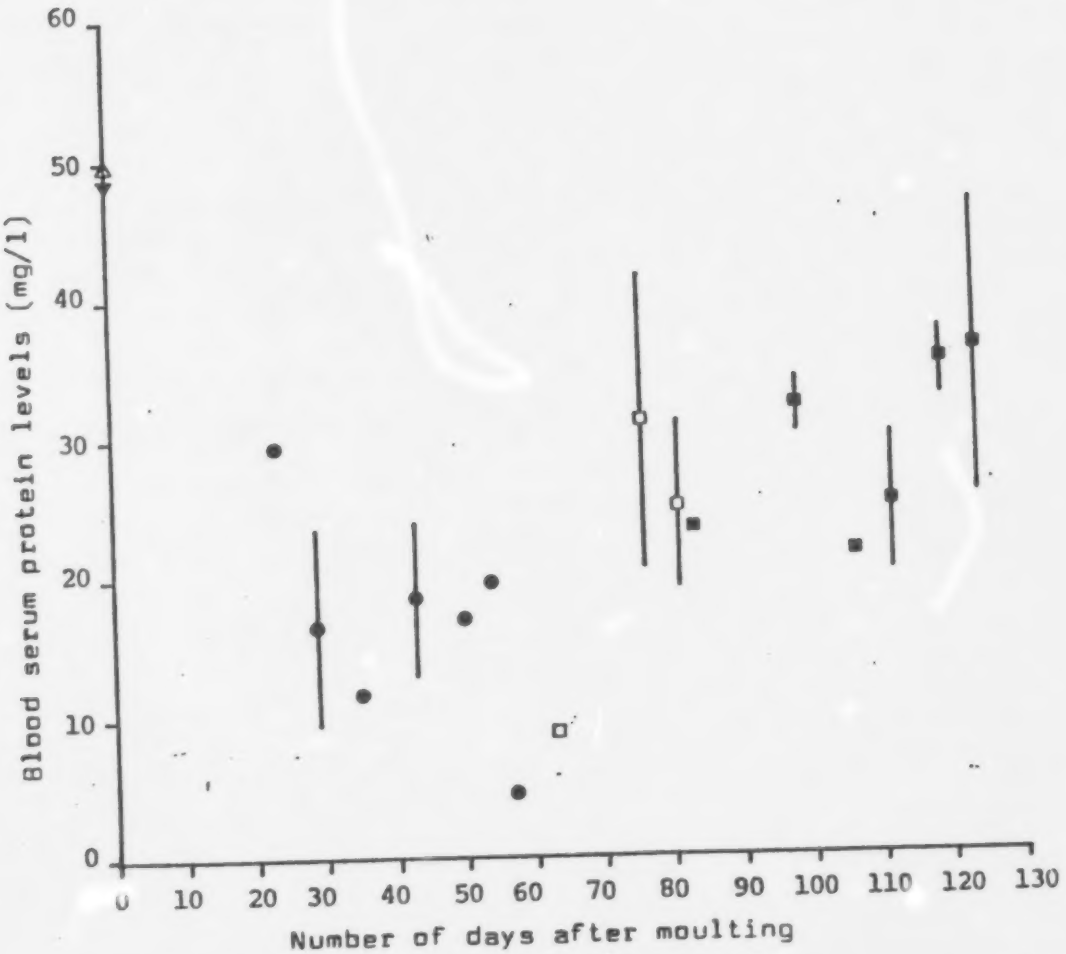


Figure 32 . Changes in blood serum protein concentration levels correlated with the number of days after moulting. For the analyses of October 16: (△) denotes non-moulters, (□) denotes first-period moulters, and (○) denotes second-period moulters. For the analyses of November 28, (▲) denotes non-moulters, (■) denotes first-period moulters, and (●) denotes second-period moulters.

It should be noted that the lobsters in the experimental group were kept from beginning to end, whereas the number of specimens in the commercial group progressively declined (figure 26). This implies that the average length of the period of cultivation for specimens in the commercial group was less than was the case for specimens in the experimental group, and that losses of claws for lobsters in the former group would have been even greater if the period of cultivation had been longer. In that case the percentage gap in losses of claws between the experimental group and the commercial group would have been wider.

In the experimental group, the number of injuries per lobster was 1.05 in mid-July, but 100% of those injuries had healed. At the end of the project, the number of injuries per lobster was substantially the same (1.05 injuries per lobster), 95% of those injuries having healed satisfactorily. It thus appears that this lobster cultivation method involves a low risk of injury to the lobsters.

7. Discussion

In the preceding chapters we have presented the survival and growth results obtained using the suspended floating system developed specifically for lobster cultivation. In this section, we shall compare our results with the results obtained using the suspended floating system designed by Fradette in 1983 (Fradette 1984 a and b).

Mortality declined from 4.2% in 1983 to 2.6% in 1984. However, it should be noted that in contrast to the 1983 experiment,

in 1984 lobsters were removed from the cultivation facility all during the project, and the effect of this was that the mortality rate was underestimated. In both years, mortality occurred mainly during the first month of cultivation, but in 1984 there was a second peak in the record of seasonal change in the mortality rate, occurring during the second moulting period; no such phenomenon had been observed in 1983. Furthermore, autopsies revealed that a large percentage of those lobsters that died in the second peak period had recently moulted. Our observations suggest that the main cause of death in these cases was the greater length of time spent out of the water during feeding operations. In 1983, the lobsters were out of the water for a much shorter time, and there was no substantial increase in the mortality rate during the second moulting period. The feeding method used in 1984 thus does not constitute an improvement, in biological terms, over the method used in 1983, and the results suggest that the length of time the lobsters are kept out of the water for feeding should be reduced to a minimum. It was probably not so much the equipment used to manoeuvre the stacks of lobster trays as the procedure adopted during the actual feeding that led to the increase in mortality during the second moulting period in 1984.

Moulting frequency and the respective proportions of moulters observed in the two moulting periods were substantially the same in 1983 and in 1984. However, in 1984 the second moulting period occurred two weeks later than had been the case in 1983. This delay may have resulted from factors beyond our control; for example, the lobsters selected in 1984 may have been less far

along in their moulting cycles than their 1983 counterparts had been. Yet on the assumption that some biotic or abiotic factor had been at work before the stocking of the lobster cultivation facility, the same factor would presumably have delayed the first moulting period as well. Looking to the method of cultivation for an explanation, we find two possibilities: the stocking period, and stress resulting from too long a time spent out of the water during feeding operations. In 1984 the stocking of the lobster cultivation facility began at least three weeks earlier than had been the case in 1983, so that the lobsters spent a greater length of time in captivity before moulting. Stress resulting from captivity may have delayed moulting in specimens that had not already reached an irreversible stage in their moulting cycles. In addition, the longer time spent out of the water during feeding operations, by subjecting the lobsters concerned to physiological stress at regular intervals, may have slowed down the progression of their moulting cycles. Both these hypotheses are based on the 1982 findings reported by Gagnon et al (1984). The stocking period and length of time out of the water were fairly similar in 1982 and in 1984, and in both years the second moulting period was characterized by a peak of intensity in October.

The weight gain observed in 1984 was less than that of lobsters subjected to equivalent treatment in 1983 (Fradette 1984 a and b). This difference was found for lobsters in all moulting cycle stage categories, and is attributable to the

difference in weight between specimens in the two years: the average weight of the lobsters selected in 1984 was greater than the average weight of those selected in 1983, and according to Fradette's findings (1984 b), weight gain varies inversely with the weight of the individual specimen. Although the gain in weight observed in 1984 was not the same as that observed in 1983, meat yields from lobsters in the various moulting stage categories were generally similar. On the whole, then, it does not appear that the improvements to the lobster cultivation system and the methods used improved or altered results in terms of growth.

Detailed analysis of the results obtained with respect to meat yields reveals that the fattening achieved during the cultivation process affects primarily the crushing claw, the yields obtained being much closer to the standard value. It would be of considerable interest to discover whether the same phenomenon occurs under natural conditions. If we knew the answer to this question, we could determine which factors relating to diet and/or method of cultivation should be improved in order to obtain meat yields that are comparable to the standard values.

The findings regarding hardness of the carapace among moulters reveal that 29% of all moulters had soft carapaces (i.e. that they had reached stage C1, C2 or C3 in their moulting cycles) by the end of the project. Unless such specimens are sold before moulting, they will be of inferior quality when marketed in December. The rapidity with which the carapace hardens probably depends on diet, i.e. the quality and quantity of the food provided and the feeding frequency. The probability that the exoskeletons of

lobsters that moult will become calcified before the end of the cultivation period is lower in the case of second-period moulters. The food intake (Fradette 1984 b) and metabolic activity of lobsters probably decline during the autumn, which is the season when the second moulting period occurs. However, our data on carapace hardness are not adequate to confirm or invalidate this hypothesis.

SENSORY ANALYSIS

1. Materials and methods

Sensory analysis tests on our cultivated lobsters were conducted toward the end of the project, on November 28 and 29, 1984. These tests were held at the premises of the laboratory of the Marine Fisheries Directorate of the Department of Agriculture, Fish and Food of Quebec in Cap-aux-Meules.

In the planning and organization of the tests, Larmond's criteria were used (Larmond 1979). The fourteen members of the sensory analysis testing committee included fisheries inspectors, restaurant owners, fishermen and scientists.

The members of the committee took part in a descriptive sensory analysis of the taste and texture of the meat and an external examination of the lobsters produced by the lobster cultivation project. For each of these tests, the participants were asked to reply to a specific questionnaire. The questionnaires used are appended to this report (Appendix 1).

The lobsters used for the taste tests were picked at random from the ranks of the first-period moulters. These lobsters were boiled in sea water for twelve minutes shortly before the tests began. The meat was then removed, and the claw meat and tail meat placed in Petri dishes. The meat of one lobster constituted one test sample. The samples were presented on serving trays with water and bread, and were served at room temperature.

For the tests relating to external characteristics, fifteen lobsters were presented, comprising five specimens taken at random from each of the three moulting stage categories, i.e. non-moulters, first-period moulters and second-period moulters. The lobsters, which were presented alive with their claws bound with elastic bands, were numbered. All the committee members examined the same fifteen lobsters, and were asked to state whether each of the fifteen was acceptable in terms of its external appearance.

2. Results

2.1 Taste test

Analysis of the results of the taste tests reveals that the meat of the cultivated lobsters was rated "highly enjoyable" (57.1%) or "moderately enjoyable" (42.9%). None of the committee members was indifferent to the taste of the meat or disappointed with the product.

A substantial percentage (42.9%) of the judges stated that there was a difference between the product submitted to them and lobster meat consumed during the lobster-catching season. Half of these persons stated that the difference was in the tail meat, 33% of them thought that it was in the claw meat, and 17% considered that there was a difference in the taste of both the claw meat and the tail meat.

The judges' qualitative descriptions of the taste of the meat of the cultivated lobsters are shown in synoptic form in

Table 6. Taste ratings of meat from cultivated lobsters

Characteristic	Inadequate		Normal or none		Excessive	
	n*	%**	n*	%**	n*	%**
Sweet	3	21.4	9	64.3	2	14.3
Salty	6	42.9	8	57.1	0	0
Bland	0	0	12	85.7	2	14.3
Bitter	0	0	12	85.7	2	14.3
Muddy	0	0	14	100.0	0	0

* : number of responses

** : percentage of responses

table 6. According to 42.9% of the respondents, the product was not salty enough. Some respondents stated that the tail meat was less salty than the claw meat. The other characteristics were generally within the normal range for the taste of lobster meat, as assessed by each of the fourteen committee members.

We also asked the participants to rate their lobster-tasting experience. Half said they were experienced tasters, while the other half described themselves as consumers. Annual lobster consumption was in the 5 to 25 bracket in the case of 92.8% of the committee members, while 7.2% of them stated that they consumed more than 25 lobsters per year.

2.2 Test on texture of meat

The respondents liked the texture of the meat better than its taste. The texture was rated "highly enjoyable" by 64.3% of the judges and "moderately enjoyable" by 28.6%. One committee member, however, rated the texture "moderately unpleasant" (7.1%).

In the view of half the committee members, the texture of the meat was different from that of the meat of lobsters consumed during the season; this impression applied to both the claw meat and the tail meat. As will be seen from the results of the descriptive analysis shown in table 7, 21.4% of the respondents considered that the meat was not juicy enough. All the other characteristics were rated satisfactory by over 85% of the judges.

Table 7. Texture ratings of meat from cultivated lobsters.

Characteristic	Inadequate		Adequate		Excessive	
	n[a]	%	n[a]	%	n[a]	%
Elastic	1	7.1	12	85.7	1	7.1
Soft	0	0	14	100.0	0	0
Firm	0	0	14	100.0	0	0
Juicy	3	21.4	11	78.6	0	0
Dry	0	0	12	85.7	2*	14.2
Grainy	0	0	14	100.0	0	0
Milky	0	0	13	92.9	1**	7.1
Doughy	1	7.1	13	92.9	0	0
Fibrous	0	0	13	92.9	1	7.1

a : number of resoonses

* : tail meat only

** : meat of one claw only

2.3 External examination of lobsters

The visual and tactile assessment tests show that hardness of carapace and the presence or absence of injuries were the main criteria on the basis of which the committee members accepted or rejected particular lobsters (table 8). The probability that a lobster would be selected on the strength of its appearance was 87.3% in the case of non-moulters, 95.7% in the case of first-period moulters, and 20.1% in the case of second-period moulters. The hardness of the carapace was deemed acceptable for over 97% of the non-moulters and first-period moulters. The second-period moulters had softer carapaces than the lobsters in the other two categories, and 51.4% of them were deemed unacceptable. Unacceptable ratings were assigned to 21.4% of the second-period moulters that had injuries. It is important to note that the injuries in question were caused by the handling the lobsters received during the tests themselves; a lobster with a soft carapace is highly vulnerable.

3. Conclusion

Analysis of the results of the sensory analysis tests enables us to conclude that a cultivated lobster is a good-quality product in terms of taste, texture and appearance. Nevertheless, some judges said that they found the meat different from that of lobsters consumed during the season. This shade of difference in taste and texture might be attributable to the lobsters' diet, the temperature at which the product was presented, or the cooking method used, which may have been different from the method ordinarily used by lobster tasters.

Table 8. Percentages of unacceptable external characteristics in cultivated lobsters from various moulting cycle categories: non-moulters, first-period moulters and second-period moulters.

Unacceptable characteristic	Non-moulters %	First-period moulters %	Second-period moulters %
Hardness	1.4	2.9	51.4
Injury	1.4	1.4	21.4
Colour	7.1	0	7.1
Epiphyte	1.4	0	0
Claw small	1.4	0	0
% unacceptable	12.7	4.3	79.9
% acceptable	87.3	95.7	20.1

Evidently there was a gradual improvement in the quality of cultivated lobsters between 1982 and 1984. In 1982, only 40% of lobsters that moulted in September were acceptable for consumption in terms of texture (Gagnon et al 1984). The results of sensory analysis tests demonstrated that cultivated lobsters were rated moderately enjoyable in 1983 (Fradette 1984 b) and from moderately enjoyable to highly enjoyable in 1984.

Analysis of the results of the external examinations reveals that non-moulters and first-period moulters would be selected for consumption. On the other hand, lobsters that moulted in the second period would be rejected because of their soft carapaces (these lobsters having reached stage C1, C2 or C3 in their moulting cycles). Referring to the moulting cycle stage situation of lobsters in the experimental group (figure 29), we must conclude that second-period moulters cannot be marketed in December because their carapaces are too soft.

The quality of the product is also contingent on the lobsters' being well fleshed out. As far as this goes, we have demonstrated that the meat yields of non-moulters are close to those of lobsters captured during the season. On the other hand, moulters are less well fleshed out than non-moulters, and in general this parameter, like carapace hardness, depends on the point reached by the individual lobster in its moulting cycle. Even so, it should be noted that a substantial number of lobsters that had moulted during the first moulting period were marketed, and that the majority of our customers appeared to find the product satisfactory.

MARKETING

1. Period of marketing

The first lobsters went on sale on July 20, after the lobster-catching season was over, and no lobsters were sold after late December, when freeze-up puts an end to lobster cultivation. The first lobsters to be marketed were female non-moulters, as these might have laid their eggs or absorbed their ovaries during the period of cultivation (Gagnon et al 1984). Subsequently, male non-moulters were offered for sale during the summer, and finally the fattened males went to market from late October onward.

2. Changes in demand and type of market

In all, we sold 5,330 lobsters totalling 2,662 kg in weight. Most sales were made in November and December (figure 33). During this period our lobsters were sold across Quebec, mainly to restaurants and fish-and-seafood markets in major centres such as Montreal, Quebec City and Rimouski. During the summer and in early autumn, most lobsters were sold locally in the Magdalen Islands (figure 33). Local demand during the summer peaked after the end of the lobster-catching season and declined progressively thereafter until October. It thus appears that most of our customers were tourists.

In December we also sold a 200-kg sample in France. Losses in transit and during subsequent handling amounted to 15%, and we tried to determine the causes. The high mortality rate among these lobsters probably resulted from changes in temperature and from the fact that the boxes in which they were shipped were too tightly sealed.

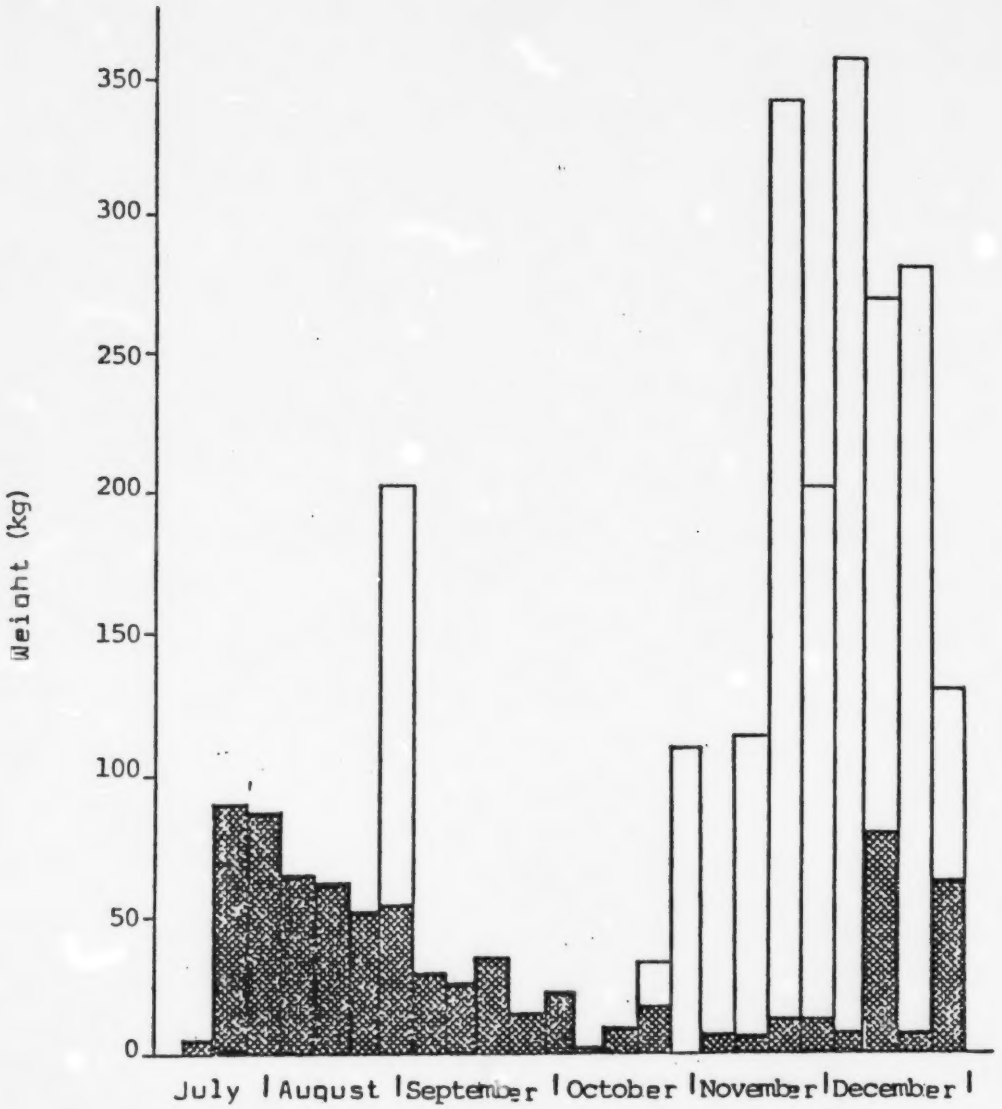


Figure 33. Seasonal change in quantities (by weight) of lobster sold per week on the local market (shaded areas) and outside the Magdalen Islands (unshaded areas).

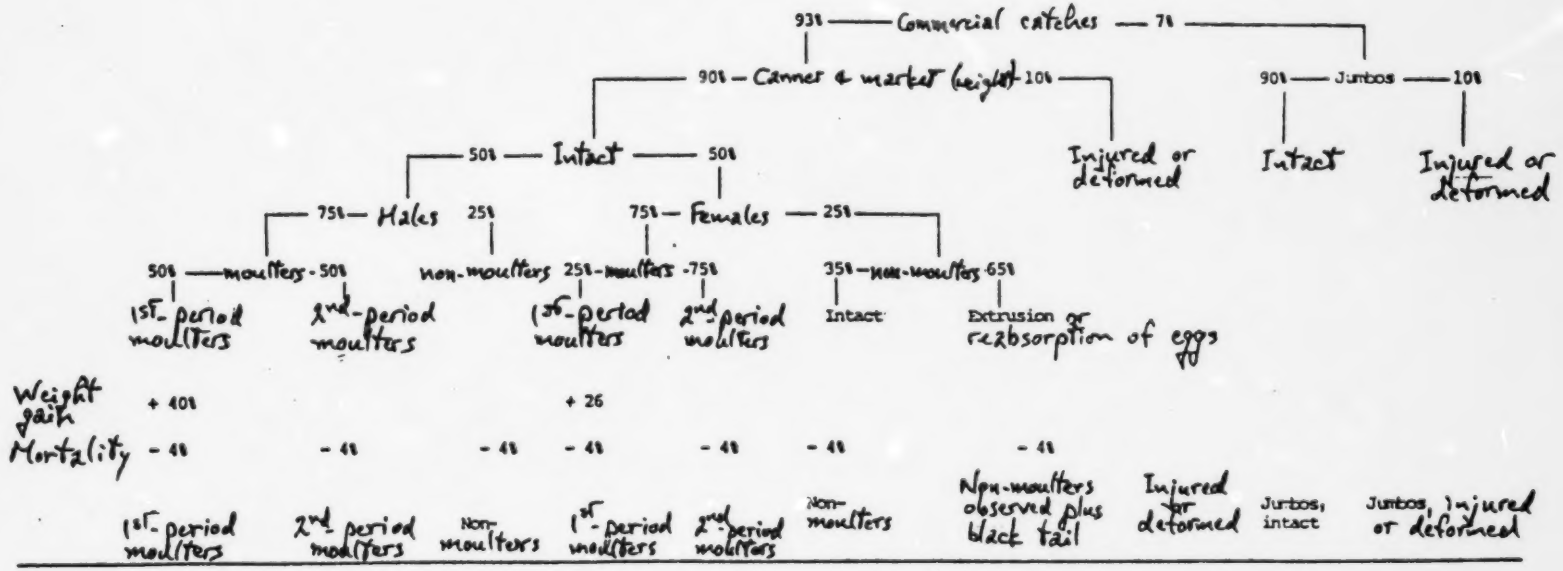
ECONOMIC FEASIBILITY STUDY

This semi-intensive system has now been developed to a point where we can produce the first economic study of a firm engaging in lobster cultivation. Lobster cultivation is defined as an extended lobster keeping and/or fattening activity resulting in weight production. We have developed four production models structured around lobster keeping or production. These models are based on current or future biological and technological knowledge.

1. Basis of models used

- The firm is already involved in the traditional lobster trade and decides to go in for lobster cultivation.
- The production unit is 31,364 kg (69,000 lbs), which is equivalent to 69,000 lobsters.
- The quantity of lobsters which the firm must buy from lobster fishermen each year in order to select the number it requires for cultivation purposes is determined from table 9.
- The cultivation facility used consists of the following components:
  - . two floating buildings with their accessories. The stacks of lobster trays are set out on both sides of the buildings, eight strings of stacks on each side. A string is 32 metres in length and may comprise 60 stacks of trays. Each stack contains 48 lobsters. The maximum number of stacks per building is 720.

Table 9. Basic data for estimating cultivated lobster production and for estimating the quantity of lobsters a firm should buy in order to select the desired number of specimens for cultivation. These data are valid only for the lobster population of the Magdalen Islands.



. it is assumed that feeding operations are mechanized and that as a result one person can feed and examine the lobsters in a stack of trays in 2.5 minutes, or in 2.0 minutes if he does not feed them but only examines them. The capacity of the system for feeding and examination operations is respectively 168 stacks of trays or 210 stacks of trays per person per day.

. the facilities are connected to a wharf by a floating walkway.

- Method of cultivation:

- Selection: the criteria used for selection of the lobsters are as follows:

. lobsters for cultivation should be selected within a few days after they have been caught,

. the lobsters selected should be free of injuries, or should have only slight injuries that have healed, and they should have both their claws,

. the lobsters selected should be of small (canner) or large (market) size.

- Food: common crabs bought from fishermen are used as food for the lobsters; the crabs are frozen, their legs are removed, and then the bodies are cut up into four portions.

- Feeding: in models in which the lobsters are fed, feeding frequency varies with the season. Optimum conditions are as follows: feeding and visual health check four times a week from July 10 to August 29, three times a week from August 30 to October 31, twice a week from November 1 to November 14, and once a week from November 15 to December 12. One crab body quarter is fed to each lobster on each occasion.

- Production: basic data for calculating production with each model are shown in table 9.

2. Characteristics of models

2.1 Model 1

- Classification of the lobsters is based on current knowledge. Moulting cannot be predicted, and accordingly all the lobsters are fed under optimum conditions.

- All the lobsters selected are males.

- The quantity of lobsters purchased by the firm every year is greater than 69,000 kg so that the desired number of specimens for cultivation can be selected.

- The objectives of the cultivation operation are the keeping and fattening of lobsters. It is desirable

for as many lobsters as possible to moult during the period of cultivation; accordingly, the entire stock is kept in captivity until the end of the first moulting period. Lobsters that moult in the second moulting period cannot be kept after moulting.

- All lobsters are placed in trays divided into four compartments; the number of divided trays required is 20,160.

- It is imperative for non-moulters to be marketed in August and for moulters to be marketed in November and December.

- The total length of the period of cultivation is 7.5 months, from May to mid-December.

2.2 Model 2

- Classification of the lobsters is based on the assumption that moulting can be predicted. Only specimens that are going to moult during the first moulting period are selected. All the lobsters are fed under optimum conditions.

- All the lobsters selected are males.

- The quantity of lobsters purchased by the firm every year is greater than 175,000 kg so that the desired number of specimens for cultivation can be selected.

- The objectives of the cultivation operation are fattening and production.

- All the lobsters are placed in trays divided into four compartments; the number of trays required is 20,160.

- The marketing period is early November to December 15. No lobsters can be marketed before the beginning of this period.

- The total length of the period of cultivation is 7.5 months, from May to mid-December.

2.3 Model 3

- Classification of the lobsters is based on the assumption that moulting can be predicted. Only specimens that will not moult during the period of cultivation are selected; the period of cultivation extends from the beginning of the commercial lobster-catching season to the end of August. By means of new biological techniques, lobsters that are shortly going to moult or extrude their eggs are identified and marketed. The lobsters are examined twice a week and are not fed.

- Both males and females may be selected.

- The quantity of lobsters purchased by the firm every year is greater than 34,000 kg so that the desired number of specimens for cultivation can be selected.

- The objective of the cultivation operation is extended keeping of the lobsters. No attempt is made to fatten them.

- All the lobsters are placed in trays divided into six compartments; the number of trays required is 13,440.

- The marketing period begins after the commercial lobster-catching season and ends on September 1. It may continue after this date if the non-moulters are kept on; in that case, however, they would have to be fed in order to maintain a meat yield acceptable to consumers. That strategy has not been included in this model.

- The total length of the period of cultivation is four months, from the beginning of May to the end of August.

2.4 Model 4

- Classification of the lobsters is based on the assumption that moulting can be predicted. At the outset, lobsters that will moult during the period of cultivation are separated from those that will not. Non-moulters and first-period moulters are selected. The non-moulters are not fed, but they are examined regularly (twice a week); the moulters are fed under optimum conditions. Techniques for predicting egg extrusion in the females are also known.

- Lobsters in the non-moulters category may be either males or females; in the moulters category, only males are selected.

- The quantity of lobsters purchased by the firm every year is greater than 69,000 kg so that the desired number of specimens for cultivation can be selected.

- The objectives of the cultivation operation are extended keeping and production by fattening the moulters.

- The non-moulters are placed in trays divided into six compartments, while the first-period moulters are placed in trays divided into four compartments; the number of divided trays required is 15,960.

- There are two marketing periods. The first runs from the end of the commercial lobster-catching season to the end of August; the non-moulters are marketed at this time. The second marketing period is in November and December, and it is during this second period that the moulters are marketed. The first marketing period may be extended on into the autumn if the non-moulters are kept and fed. That strategy has not been included in this model.

- The total length of the period of cultivation is 7.5 months, from the beginning of May to mid-December.

3. Profitability study

3.1 Main assumptions

- Sales: The selling price is $5.00 per pound from July 10 to August 31. The selling price is $6.00 per pound from November 1 to December 15. The selling price includes transport costs and the cost of boxes.

- Purchases: The purchase price is $2.35 per pound.

- Food: The price of common crab is $0.10 per pound.

- Freezing and storage: The cost comes to $0.10 per pound.

- Direct labour costs: Wages paid average $300 per week, fringe benefits included.

- Selling costs: Selling costs include:
  - transport and delivery, $0.32 per pound,
  - boxes, $2.50 per 30 pounds

- Equipment and facilities: We have assumed that the promoter possesses:
  - one shed
  - one truck

  and that the location selected is such that an access ramp can be installed.

3.2 Operating budget

	MODEL			
	1	2	3	4
Buildings (2 units at $30,000 each)	$60,000	$60,000	$60,000	$60,000
Lobster trays:				
20,160 at $8.00	161,280	161,280		
13,440 at $8.00			107,520	
15,960 at $8.00				127,680
Wooden frames and screens				
18,780 at $3.25	60,840	60,840		
12,480 at $3.25			40,560	
14,820 at $3.25				48,165

Machinery				
(2 units at $20,000 each)	40,000	40,000	40,000	40,000
Straps				
1,440 at $6.00	8,640	8,640		
960 at $6.00			5,760	
1,140 at $6.00				6,840
Floats				
1,440 at $8.00	11,520	11,520		
960 at $8.00			7,680	
1,440 at $8.00				9,120
Handling tubs				
12 tubs at $25.00	300	300	300	300
TOTAL	$342,580	$342,580	$261,820	$292,105
ANNUAL DEPRECIATION	$ 50,470	$ 50,470	$ 36,990	$ 42,045
FINANCING COSTS				
342,580 x 13%	$ 44,535	$ 44,535		
261,820 x 13%			$ 34,037	
292,105 x 13%				$ 37,974

3.3 Projection of operational results

	MODEL			
	1	2	3	4
SALES	$415,656	$556,416	$331,200	$415,656
EXPENDITURES				
Purchases of lobsters	162,150	162,150	162,150	162,150
Food	31,695	51,069	-	18,707
Freezing and storage	31,695	51,069	-	18,707
Direct labour costs	90,000	88,240	30,350	55,450
Depreciation	50,470	50,470	36,990	42,045
Financing costs	44,535	44,535	34,037	37,974
Miscellaneous	5,000	5,000	5,000	5,000
	415,545	452,533	268,527	340,033
GROSS PROFIT	111	103,883	62,673	75,623
SELLING COSTS	30,724	37,404	26,717	30,724
OPERATING PROFIT (LOSS)	$(30,613)	$ 66,479	$ 35,956	$ 44,899

4. Conclusion and remarks

This profitability study is designed for a conventional producer who has decided to go in for cultivated lobsters as part of his production operation.

The four models are based on the assumption that the lobster feeding and examination operations are mechanized. The mechanized system described in this report is inadequate and would have to be further developed before it could meet the standards set forth in the chapter on the basic data used in the models.

From a biological standpoint, model 1 is the only one that could be applied immediately, as it is the only one that is based on currently available knowledge; unfortunately, it is also the only production model that is unprofitable. Accordingly, before cultivated lobster production will be economically advantageous, further research is required, leading to a reliable technique by means of which moulting can be predicted. Biological techniques to this end and more satisfactory mechanization could be developed simultaneously.

Equipment cost figures are based on very sketchy estimates, inasmuch as the necessary machinery has not yet been invented, and consequently its cost cannot readily be estimated. In order for this type of lobster cultivation to generate profits, the size of the investment required must be reduced. There are three possible ways this might be done:

1 - by reducing the cost of the necessary equipment,

2 - by increasing the efficiency of the equipment used,

3 - by obtaining subsidies for the equipment used.

Every producer who is interested in a lobster production operation should check his own costs, as costs may vary from one producer to another. By way of example, the prices paid for lobsters, food and freezing may vary considerably.

For a very small firm, model 3 affords a possible means of producing cultivated lobsters. With models 1 and 4, the firm would have to buy twice as many lobsters from fishermen as in the case of model 3, and with model 2 it would have to buy five times as many.

As regards the quantities of food required with the various models, the order is model 3, model 4, model 1 and model 2, the smallest quantity being required with model 3 and the largest with model 1.

The smallest number of lobster-days is found with model 3; the ranking of the others is, in ascending order, model 4, model 1 and model 2.

Model 4 makes provision for the most extensive marketing period, with model 1 coming next and models 2 and 3 ranking equal third.

The total length of the period of cultivation is shorter with model 3, being only four months as against 7.5 months for the other models.

The relative weight of each of the above-mentioned factors will enable a firm to select the model that minimizes economic risk in its particular case.

RECOMMENDATIONS

1. Technological improvements

- Automation of:
  (1) the system used for handling the stacks of lobster trays,
  (2) the system of access to the trays containing the lobsters,
  (3) food preparation and insertion of portions of food into the lobster trays.

- Better access to the floating building with a view to reducing the time spent making trips back and forth.

- Reduction to a minimum of the length of time the lobsters are out of the water at feeding operations, primarily during the moulting period.

- A new lobster tray designed to eliminate the losses of time resulting from (1) adjustment of the ballast in order to maintain the buoyancy of the stacks of trays, and (2) the replacement of damaged parts (tray, wooden frame, screens).

2. Biological improvements

- Application of Fradette's recommendations on feeding (Fradette 1984 b) in order to upgrade the quality of the lobsters.

- Development of a method of predicting when a lobster is going to moult. The method should not result in injury to the lobster concerned and should be quick. If moulting were predictable, the lobsters could be divided into three categories: first-period moulters, second-period moulters, and non-moulters. Lobsters in each category could be fed a suitable diet. Dividing up the lobsters in this fashion would facilitate the selection of specimens for marketing. Second-period moulters could be marketed from the end of the commercial lobster-catching season to late August. Non-moulters could be marketed at any time. It would be preferable to keep non-moulters and second-period moulters in an appropriate system without attempting to fatten them.

- The potential quality of lobsters that moult during the second moulting period is inferior to that of non-moulters and first-period moulters. Both Fradette's findings (Fradette 1984 b) and our own suggest that second-period moulters are generally unacceptable because of their unsatisfactory meat yields and inadequately hard carapaces. Consequently, these lobsters should be marketed before they moult.

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APPENDIX 1

TASTE TEST

NAME: _____ NO. OF LOBSTER: _____

OCCUPATION: _____ DATE OF TEST: _____

TIME OF TEST: _____

PLEASE READ THIS QUESTIONNAIRE CAREFULLY BEFORE PROCEEDING WITH THE TEST.

1. Please taste your sample and indicate to what extent you like or dislike its taste. Note that the texture is to be disregarded, as only the taste is to be rated.

I find the product highly enjoyable ____

moderately enjoyable ____

The product leaves me indifferent ____

I find the product moderately unpleasant ____

highly unpleasant ____

REMARKS: _____

_____

2.(a) Do you notice any difference between this product and lobster meat consumed during the lobster-catching season? (This question also refers to taste only.)

YES NO

If your answer is "yes", please answer question 2(b).

(b) Is the difference noticeable in the claw meat? ____

in the tail meat? ____

in both the claw meat and the tail meat? ____

(c) How would you rate the taste characteristics of this product?

	Inadequate	Normal	Excessive
Sweet	____	____	____
Salty	____	____	____
Bland	____	____	____
Bitter	____	____	____
Muddy	____	____	____

Other (specify): _____

_____

3. (a) Would you describe yourself as:

an expert? ____

an experienced taster? ____

a consumer? ____

(b) Approximately how many fresh lobsters do you consume per year?

1-5 ____

5-25 ____

more than 25 ____

VISUAL AND TACTILE ASSESSMENT TEST ON LOBSTERS

Please indicate, for each lobster shown to you, whether you consider it acceptable or unacceptable on the basis of your personal selection criteria.

Number of lobster:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Acceptable:															
Unacceptable:															

In the case of any lobsters you consider unacceptable, please indicate the number(s) of the lobster(s) concerned and the reason(s) for your decision.

Number(s) of lobster(s) considered unacceptable	Reasons(s)

LES CRUSTACES VIVANTS MADELINOTS THANK YOU FOR YOUR CO-OPERATION

SENSORY ANALYSIS RATING OF MEAT TEXTURE

NAME: _____ NUMBER OF LOBSTER: _____

OCCUPATION: _____ DATE OF TEST: _____

TIME OF TEST: _____

PLEASE READ THIS QUESTIONNAIRE CAREFULLY BEFORE PROCEEDING WITH THE TEST.

1. Please taste your sample and indicate to what extent you like or dislike its texture. Note that the taste is to be disregarded, as only the texture is to be rated.

I find the product highly enjoyable ____

moderately enjoyable ____

The product leaves me indifferent ____

I find the product moderately unpleasant ____

highly unpleasant ____

REMARKS: _____

_____

2. (a) Do you notice any difference between this product and lobster meat consumed during the lobster-catching season? (This question also refers to texture only.)

YES NO

If your answer is "yes", please answer question 2(b).

(b) Is the difference noticeable in the claw meat? ____

in the tail meat? ____

in both the claw meat and the tail meat? ____

(c) How would you rate the texture characteristics of this product?

	Inadequate	Adequate	Excessive
Elastic	___	___	___
Soft	___	___	___
Firm	___	___	___
Juicy	___	___	___
Dry	___	___	___
Grainy	___	___	___
Milky	___	___	___
Doughy	___	___	___
Fibrous	___	___	___

Other (specify): _____

_____